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EDITORIAL.

ITEMS AND NOVELTIES.

The Wharton Safety Railroad Switch—BY WILLIAM H. WAHL.*—Any invention or discovery which in any degree serves the purpose of throwing some additional safeguards about railroad travel, becomes so much a matter of personal interest that no preliminary remark is necessary to introduce it to the notice of the reader. One of the most useful and popular of American inventions in this direction is the Wharton Safety Railroad Switch. The inventor has succeeded in producing a mechanical device which has proved itself in practice to realize so nearly the conditions of perfect safety, that there is now no valid reason or justification to be offered for that most common of excuses in railway disasters—"a misplaced switch." That the merits of the invention are recognized, is evinced from the fact that many of our best railroad companies have adopted it upon their entire lines to the exclusion of all others. The chief objects accomplished by the device consist in leaving the main track of the road entirely undisturbed and continuous, and in securing—as nearly as such a thing is possible in practice—perfect safety to trains, should the switch, either by accident or design, be left wrong; and this without injury to the switch.

* From the Am. Exchange and Review, October, 1872.

The accompanying illustrations show the switch in its two positions. Fig. 1 shows the switch open and entirely removed from the main track. Fig. 2 shows it closed and in position to transfer cars from the main track to the siding. The essential parts of the switch are the two switch-rails, a fixed and a movable guard. One of the switch-rails, it will be observed, is of a peculiar grooved form with a pointed end, which lies just within the head of the main track rail. The function of this arrangement will shortly appear. The switch-rails and the movable guard rail, which are in connection with each other, may be removed entirely away from the main rails, when not required (Fig. 1), when they neither touch, nor in any manner act upon the car wheels, and for all practical purposes no switch is present. When moved in the position of Fig. 2, the switch is ready to act in transferring cars to the siding. The operation would be about as follows: The train moving in the direction of the arrow, would pass the switch upon the main tracks, when the switch would be closed (Fig. 2) by an attendant, and the train backed down into it. The fixed guard would first come into play in slightly drawing the wheel on the opposite side away from the main rail, so that its flange may certainly pass *inside* the grooved switch-rail. The opposite wheel being now pressed up against the main rail on its side, a portion of its outer tread is brought to bear upon the switch-rail directly aside the main track. This switch-rail, however, slightly inclines upwards, so that the wheel in its passage is quietly raised, and in the space of four and a half feet rests entirely upon the outer switch-rail; its flange having passed up an incline sufficient in height to raise it entirely above the main track rail. The opposite grooved switch-rail has, during the same time, performed for the opposite wheel the same function; so that the wheels being now upon the siding, the transfer is practically accomplished.

The cranks attached to the shaft of the operating mechanism are fixed at such an angle with each other, that while the pin holding the switch is upon the dead-centre, or slightly below it, that at the other end is at such an angle that it can be readily operated by the connecting rod from the movable guard-rail. Any lateral pressure, therefore, applied to the switch-rails will only have the effect of pressing the lever which operates them, more firmly down upon the cross-tie on which it rests, and thus hold the rails more strongly in position.

After the operation of transferring a train to the siding is effected, it is intended that the switch should be returned again to the open

Fig. 1.

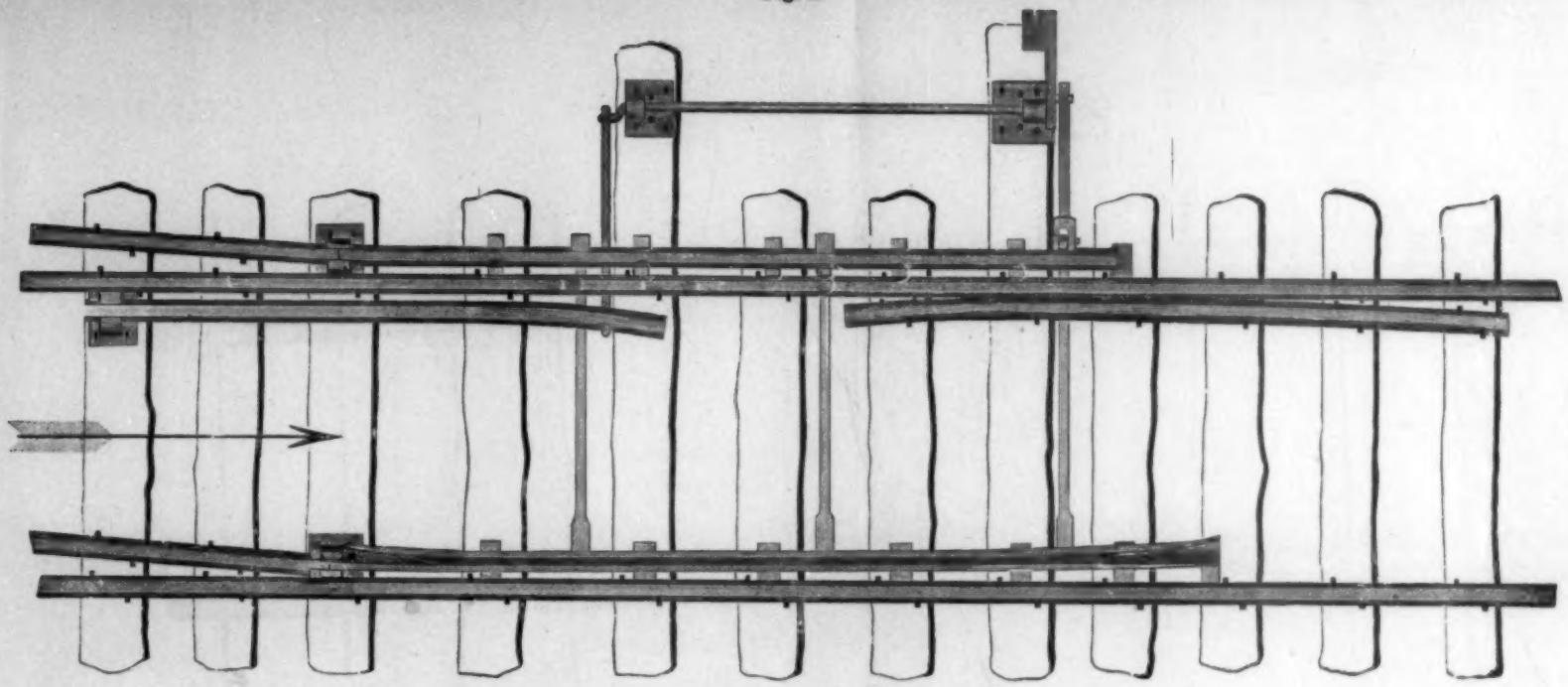
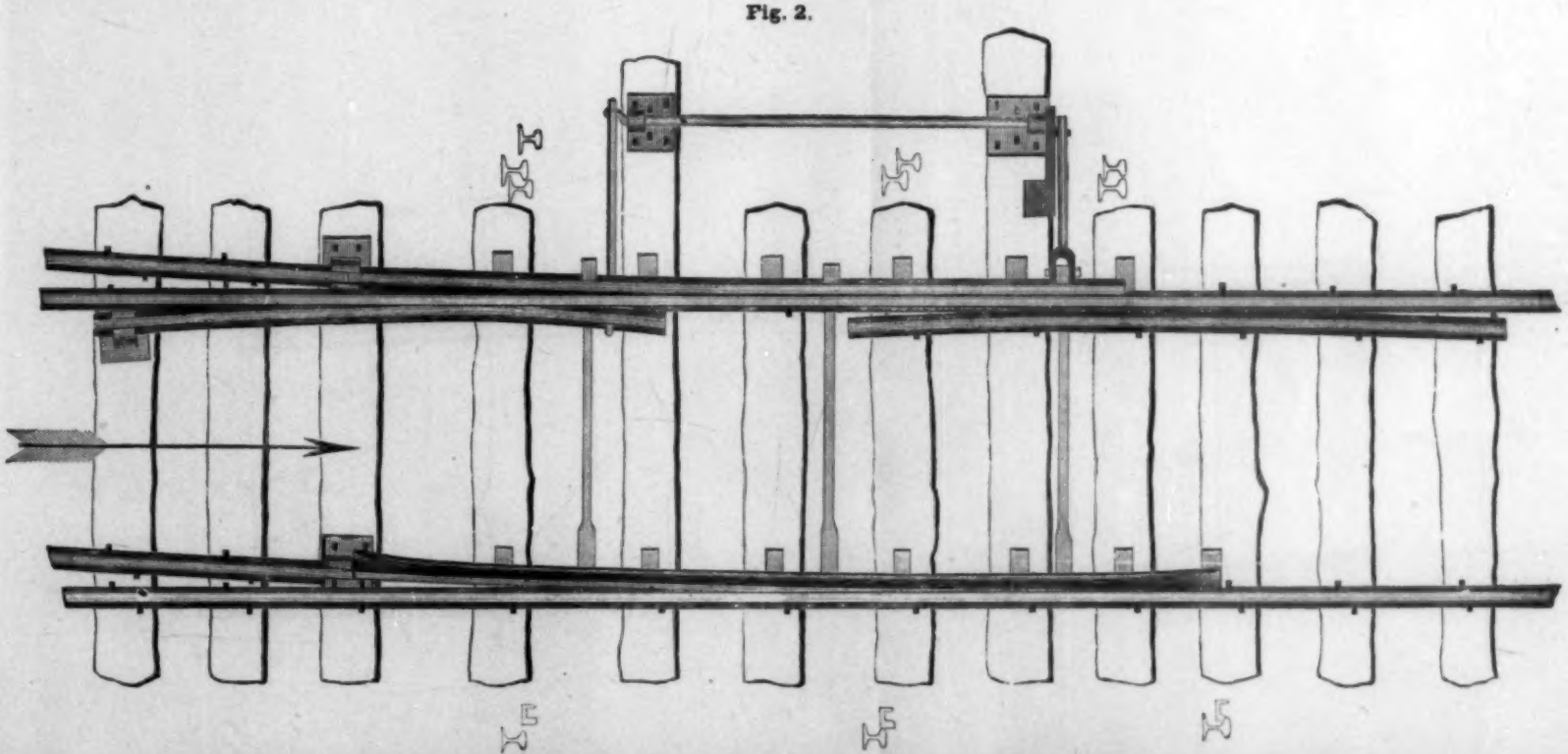


Fig. 2.



THE WHARTON SAFETY RAILROAD SWITCH

position of Fig. 1. But, supposing that either through accident or design it should remain unchanged, it is impossible that an accident should occur, from the provision which the invention affords for completely meeting such a contingency, should a fresh train arrive (of course in the direction of the arrow), with the switch misplaced; the engine wheel bearing against the inner edge of the movable guard-rail would readily operate the favorably placed crank connecting the same with the switch-rails, and these would be instantly moved clear from the track in the position of Fig. 1, leaving the latter free for the passage of the train. The accidental starting of a train just switched off could also be followed by no further evil than its running again upon the main track. Should the switch be left open by accident or design after a train has been run upon the siding—instead of being closed, as it should be—there are two siding castings called guards (not shown in the engravings), which bring the train on the siding safely back again on the main track. In no case is it possible for an accident to occur from the action of the switch, unless we except the possibility of such stupidity as the running one train off upon the siding into another; and even this danger may be obviated thus: Where a single track is to be provided for, the switch will not remain set for the siding; for, by the introduction of a simple device, the presence of an attendant is required to keep the apparatus in position to act as a switch. As soon as the attendant releases his hold, the switch-rails return to their open position, leaving the main track clear—thus securing the safety of trains moving in both directions.

It will readily be perceived by those acquainted with the subject, that other advantages, involving the question of economy, are to be considered, in addition to that of safety, in enumerating the superior merits of this invention. From this point of view, the saving in wear and tear of the rolling stock from the constant jolting which accompanies the use of the ordinary switch, as well as that of the switch itself, form prominent points for consideration.

As one of the many indications of the favor with which it has been received in official railroad circles, the following letter, from Col. Thos. A Scott, will serve the purpose.

PENNSYLVANIA RAILROAD COMPANY,
OFFICE OF THE VICE PRESIDENT.

Philadelphia, January 25th, 1871.

A. BARKER, Esq., President Wharton R. R. Switch Co.

My Dear Sir.—After careful experiment upon our road at several points where it could be most thoroughly tested, during which you have perfected the

Wharton Railroad Switch, so that we think it adapted to all our wants, we have concluded to adopt it on our own road and the roads leased by us; and will give it place as rapidly as we can do so consistently with the proper maintenance and operation of the line.

I believe that it will prove of great practical value to all the Railways of the country. Very respectfully yours,

THOMAS A. SCOTT, *Vice-President.*

Besides this valuable endorsement, it has also received from numerous other prominent railroad managers equal commendation. All the wearing parts being constructed of Bessemer steel, the switch is extremely durable. Targets and signals of any kind, for indicating the position of the switch, are rendered entirely unnecessary.

The Howard Super-heated Air Engine.—We give, with the accompanying illustrations, a brief description of this somewhat novel form of motor, which attracted considerable notice at the recent industrial exhibition of a neighboring city.

Referring to Fig. 2, a vertical section—Fig. 1 being a perspective view—A represents the induction valve of the air-pump, and B, the air-pump plunger. C and D are stop-valves in the air-passage from the pump to the fire-box. The air-passage has two branches. The branch, E, leads to the fire-box, and the branch, F, is the exhaust passage from the cylinder of the engine leading back to the general passage, of which G is the exhaust port. The valve which opens or closes the port, G, is actuated by a cam, H, and a suitable connecting rod. I is the piston of a hot-air cylinder. This piston is lined with soapstone, and so made that a little annular space is left between it and the upper half of the cylinder, except at the top, where it meets the cylinder to form an air-tight packing. The lower part of the cylinder is thickly lined with soap-stone, as is also the fire-pot immediately below it. The exterior of the hot-air cylinder is protected from the heat by a cold-water jacket. The heat, however, is not so intense but that this jacket may be dispensed with.

J is a shaft which, driven from the cone pully on the fly-wheel shaft, operates the coal-feeding apparatus by an automatic arrangement. The coal is placed in the hemispherical receptacle, K. A semicircular feed-bar, M, oscillates on a pivot, and at each oscillation raises on its inner end a small modicum of coal. A wire brush, N, which has a horizontal movement, brushes off the coal thus raised into the open mouth of the cock, or gate, L, the latter being so constructed that it completely closes the passage to the fire-box, both when receiving the coal and when delivering it into the cylindrical passage in front of the

FIG. 2

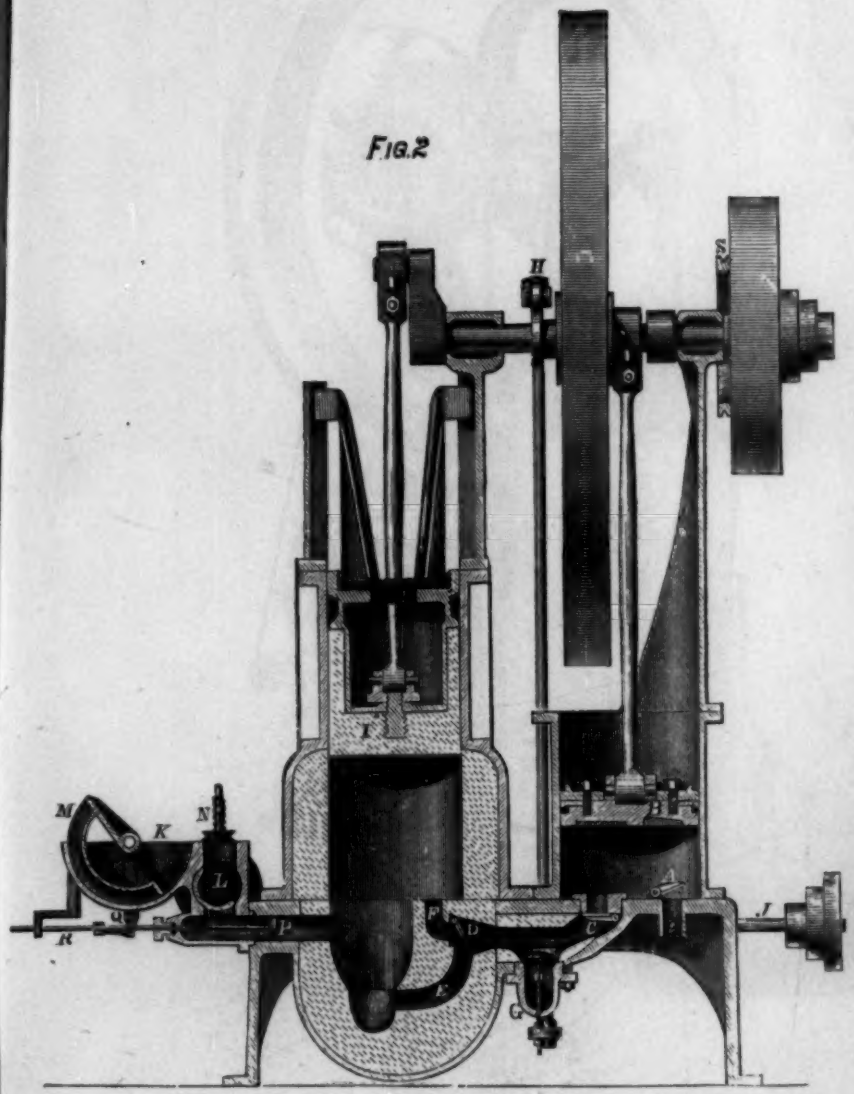
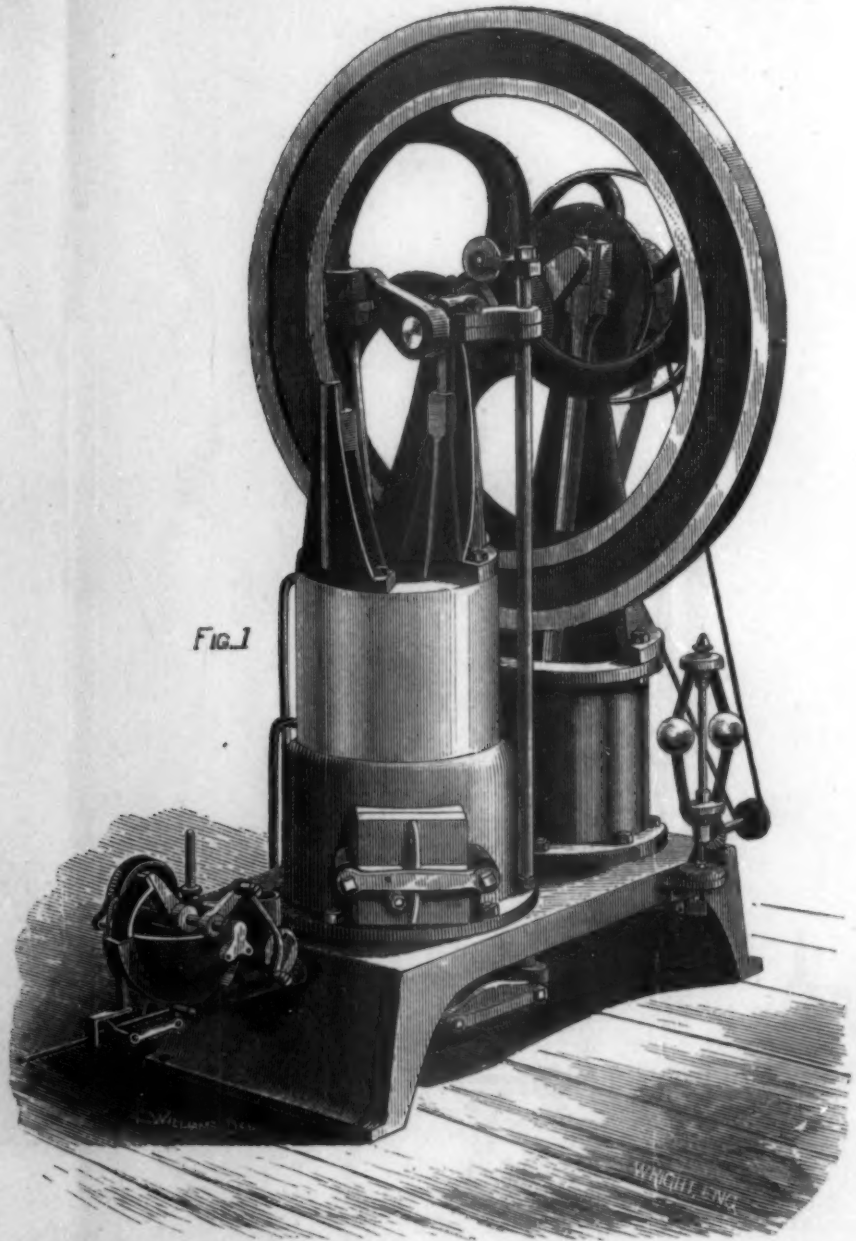


FIG. 1



THE HOWARD AIR ENGINE.

plunger P. The plunger, P, is actuated by an arm, Q, linked to the rod, R. When the fire-box is full, the plunger, P, meets so much resistance as to prevent its reciprocation. It then causes the belt to slip on the cone pulleys, and thus retards the feeding.

O is a damper placed in the port of the induction-valve of the air-pump. This damper is controlled by a governor, shown in Fig. 1, and which is driven from the grooved pulley on the fly-wheel shaft. When the damper closes, it causes a partial vacuum in the cylinder of the pump, resisting the ascent of the piston, and thus reducing the power of the engine, and vice versa.

The operation of the engine is as follows:

As the pump-piston rises, air enters at A to fill the pump-cylinders. The cranks of the pump-piston and the hot-air cylinder-piston are set at right angles. It follows that on the descent of the pump-crank to the lower centre, the hot-air piston will have passed the bottom centre, and will be at mid-stroke. When the pump-piston is at mid upward stroke, the hot-air piston-crank will be at the upper centre, and the hot-air piston will be at the end of its upward stroke. When the pump-piston arrives at the end of its upward stroke, the hot-air piston will be at mid-downward stroke, and when the pump-piston is at mid-downward stroke, the hot-air piston is at the end of the downward stroke, being brought to that position by the motion of the fly-wheel. When the hot-air piston is at the end of the upward stroke, the exhaust takes place. The hot-air piston then descends to mid-stroke, when, the pump-piston beginning to descend, the cold air from the pump-cylinder exhausts, together with the hot air from the hot-air cylinder, the mingling of the cold and hot air so far reducing the temperature that the exhaust-valve is not injured.

The exhaust closes a little in advance of the full descent of the hot-air piston, and also a little before the pump-piston reaches the mid-downward stroke, giving a little compression. Then, as the pump-piston is traveling rapidly downward, while the hot-air piston is rising slowly, having just passed the center, the air is condensed somewhat by the force of the fly-wheel. As the hot-air piston rises rapidly after passing the lower center, the pump forces the air remaining in it into the fire-pot. The rapid expansion of the air in heating now forces the hot-air piston upward.

The valve, A, is of brass, faced with leather; and to prevent its noisy fluttering, it is operated or steadied by a light steel finger, manipulated by a delicate cam and rod not shown in either view. The

valve, C, opening within the passage, is simply of brass, and is accessible from the inside of the pump by removing the seat. The pump piston is packed with the best oak-tanned cap leathers, carefully turned and fitted, and is claimed to require no attention beyond being lubricated, for long periods of time. The valve, G, requires to be reground to its seat once in six months, only the work of twenty minutes. The valve, D, is simply a damper valve, made of light Russia iron, and does not require to be air-tight.

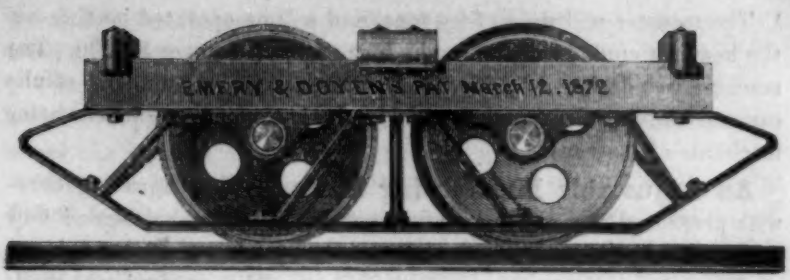
The packing found most convenient is the common soapstone packing. The cylinder being open at the top, it is very convenient to apply a small portion of tallow, or tallow and beeswax, occasionally. The packing is kept screwed down by means of a follower ring turned with a spanner.

For the engine here described as fully as space will admit, the manufacturers claim a number of advantages, among which are those of simplicity, durability and compactness. They build an engine of 6-inch cylinder, which is strongly recommended for a great variety of light work, and especially as a pumping machine for household work. This small engine was on exhibition at the late American Institute Fair in New York city, where also are located the head-quarters of the manufacturers.

The Hoosac Tunnel.—To the record which we have presented from time to time of the progress of this interesting engineering project, we can now add a piece of information which carries with it the intimation that the "beginning of the end" is at hand. On the 12th of December, after some unusually heavy blasting, a union was effected between the workings on the east end of the tunnel and the central shaft.

The great hindrance caused by water in the central shaft, and which has repeatedly caused serious stoppages in the work at this part of the tunnel, besides the expense attendant upon the erection and constant operation of pumping machinery, is now at an end; the waters having now a free drainage into the Deerfield river. From present indications, the remaining portion of the boring, viz., four thousand feet between the west end and the central shaft will be completed, and the tunnel ready for use by October, 1873, or three months within the period agreed upon by the contracting parties.

A Safety Shoe for Railway Cars, etc.—In the last issue of the "Journal," attention was called, in a brief item, to this invention, which had been for some time on exhibition in the city.



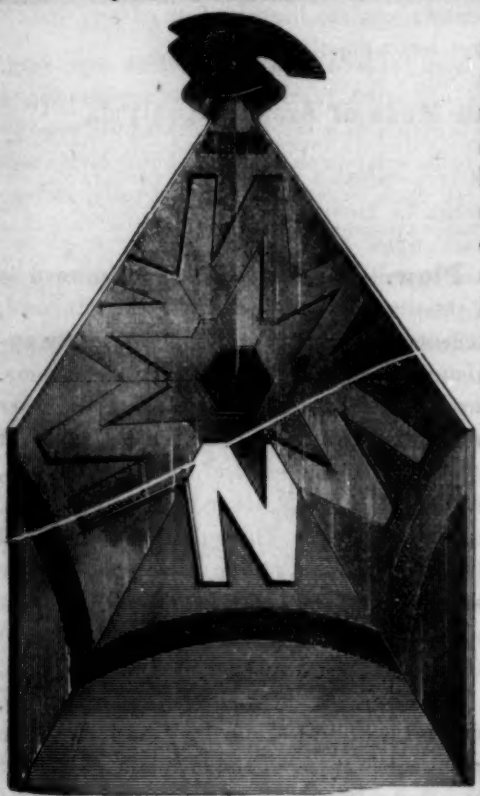
Since that time we have been favored with an excellent engraving, showing the device in side elevation, from which the appearance of the new attachment and its function as a safety apparatus will readily be observed. There seems to be some probability that the device will soon receive a practical test upon several of our railroads, and we shall await the results of such experiments with interest.

An Enormous Snow Plow.—The Union Pacific Railroad is having built, at its shops at Omaha, a snow plow which, when finished, will be the largest and most powerful in the world. It is rapidly approaching completion, and in a few days will be ready for business. The trucks on which it is built are very heavy and strong, and were cast especially for this plow. The platform on these trucks is 22 feet long, and 10 feet 6 inches wide, and is composed of solid oak timbers, 8 by 16 inches. These timbers are held together by ten iron bolts, 1¼ inches in diameter, which run crosswise. This solid bed is fastened to the transom beams by forty bolts, twenty over each truck. The inclined slide, placed on the platform, is 22 feet long, and slopes at an angle of 30 degrees, and is held firmly to the bed by 40 bolts, of an inch in diameter, and is supported from behind by inclined posts, 6 feet long, 8 inches wide, and 16 inches thick. The entire length, from the rear of the platform to the end of the slide, is 32 feet. The slide is to be ironed, and an immense plow, of the ordinary shape, 18 feet long, 11 feet wide, and 5 feet high, and covered with iron $\frac{3}{16}$ of an inch thick, is to be securely placed upon it. On the point of this plow there is to be an iron plate, steel pointed, 11 feet long and four feet wide. This plate runs across the track, and only 1 inch above it.

The rear of the platform will be boxed in, making a room 12 feet high, 11 feet wide, and 10 feet long, for the purpose of keeping the snow out. It will be furnished with a door, so that if necessary it can be loaded with iron.

The monster will weigh fifty tons, and will be operated by three of the heaviest engines on the road. The cost will be over $5,000. The machine was designed by Mr. G. E. Stevens, Superintendent of the car and building department, and Mr. J. H. Congdon, general master mechanic of the road.

An Adjustable Multiplying Mirror.—The engraving herewith presented represents an arrangement of mirrors, designed and patented by Mr. Bielefeld, the well known optician of Philadelphia.



The engraving, which is a slight reduction of the instrument, shows two metallic plates with inner surfaces silvered, and highly polished. These are arranged to open and close, having a movement of 90°, by means of a hinge shown at the top. This is formed by the appropriate folding upon each other of a small extension of each of the plates, and securing the same with a rivet. The upper surface of the hinge is flat, and upon the lower of the two is brought a graduation from zero to 90°, while the extremity of the upper fold is fashioned into an index, which, upon moving the mirrors, travels over the graduated arc, and indicates their angular aperture.

It will be apparent that we have here an instrument by which an object placed between the mirrors will be multiplied any desired number of times. When placed at right angles, the mirrors will show, besides the object, three images or reflections of it; at 60°, besides the object, five images; at 45°, seven images, etc.—thus combining the kaleidoscopic effect, with the means of varying the appearance and

intricacy of combinations, derivable from one and the same design as a basis.

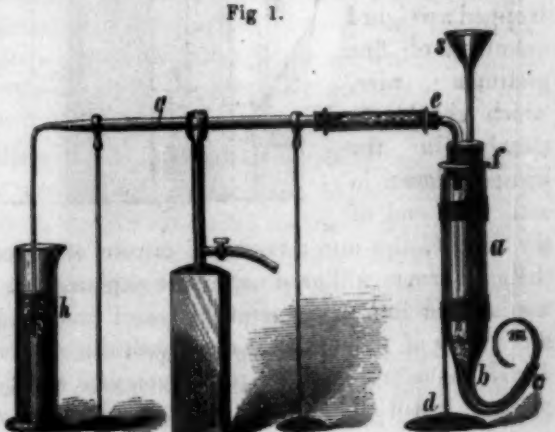
The inventor has intended the instrument to be of service to designers of patterns for textile fabrics, etc.; for artists, draughtsmen as well as a useful adjunct for instruction in schools.

There can be no question that for the first of these uses, the facility with which a happy pattern can be modified indefinitely by the adjustable property of this device, will prove of much convenience and advantage; while, as a scientific toy, the beauty of its effects, and its portability, will doubtless render it popular.

Improvements in the Mode of Arsenic Analysis.—Prof. John C. Draper has communicated to several of our contemporaries an article containing some very valuable suggestions concerning the modes of determining arsenic in medico-legal investigations. The suggested improvements are upon the method usually employed, namely, the precipitation of metallic arsenic from its gaseous compound with hydrogen.

Recognizing the great difficulty of securing pure zinc for the purpose of the Marsh test, the author has suggested the substitution for it of magnesium. For this purpose he has somewhat modified the apparatus usually employed, and constructs it as shown in fig. 1, in which the generating vessel is formed of a glass tube, drawn out tolerably thin at its lower part. This is curved upwards, as shown, and the bottom of the vessel covered to some height with mercury, which will, of course, sustain the higher column of acid subsequently added in the tube. At *e* is a drying tube; and at *g*, the reduction tube; while any arsenic escaping reduction with the lamp in this,

Fig 1.

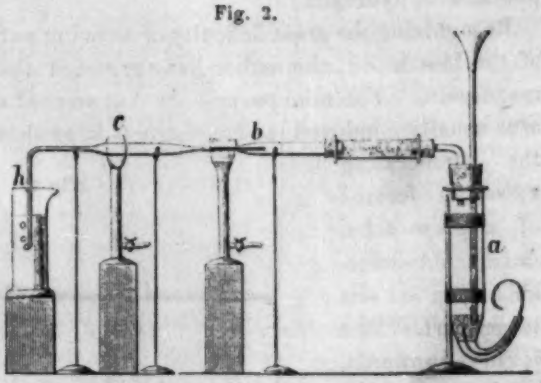


is caught up in the flask *h*, beyond which contains some nitrate of silver.

The operation of the device is as follows: The magnesium, in form of a band, is fed up into the tube *a*, by hand, through the quicksilver, as rapidly or slowly as may be required by the energy of the gas evolution; and the resulting gas is tested by the reduction flame for considerable time, in order to assure a confidence in the purity of the reagents employed. After this has been determined, the suspected liquid is fed in, in known quantity, through the funnel *s*, and the reduction test effected.

As, in most cases of arsenical poisoning, it is desirable to obtain all the arsenic found in an organ of the body, at one spot, in order that it may be first accurately weighed before being subjected to the action of subsequent tests, the author has arranged for the introduction into the reduction tube of a faggot or bundle of platinum wire. Upon these wires the whole of the arsenic, if any be present, is deposited. Fig. 2.

Fig. 2.

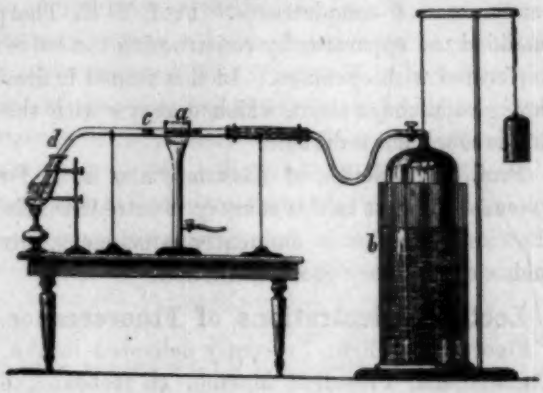


It consists of a hard lime glass tube drawn down at *b* to one-tenth of an inch, into this fine space are dropped a weighed quantity of fine platinum wire, which should fit closely in the manner shown in cut. The end of the tube, *h*, dips into a vessel of nitrate of silver. The position of the gas-burners will need no further explanation. After the introduction of acid into the generating vessel and the preliminary test for the purity of the materials employed, the suspected liquid is introduced as before and the test proceeded with; when, if arsenic is present, it will all be found upon the platinum, and its weight determined by the gain in weight of the platinum faggot which is removed from the tube for this purpose. The vessel of nitrate of silver is for the same purpose as that in the previous case.

Fig. 3 shows the device employed to remove the metallic arsenic from

the platinum and to convert it into arsenious acid, for the purpose of subjecting it to further tests as to its identity.

Fig. 3.



The faggot of platinum is placed in a tube of the form shown at *a c d*, and heated by the gas flame, while at the same time a current of dry oxygen gas is passed over it from the gasometer, which is shown attached. By this means all the arsenic is volatilized from the metal at a dull red heat, and recondenses as arsenious acid at a point, *c*, beyond the flame. The small portion which escapes condensation here may be caught by leading the open end of the tube into water kept moderately boiling at *d*.

We believe the device, here very briefly described, possesses quite a number of points of advantage, both in its freedom from several of the drawbacks incident upon the ordinary method employed, and in its neatness and convenience of form. It seems to be in every way worthy of recommendation to the analytical chemist as a standard piece of apparatus for the purpose for which its experienced designer has intended it.*

An Improved Filter Pump.—Dr. Mendelejef recently described, before the Chemical Society of Berlin, a modification of the Bunsen filter pump, which, besides rendering this laboratory adjunct portable, also greatly adds to its simplicity and serviceability. The gist of the improvement consists in bringing, at the junction of the water-pipe with the branch tube connecting with the vessel to be exhausted, a valve devised originally by Bunsen, and known to chemists as Bunsen's valve. By this means the necessity for a considerable fall of water is done away with, as well as the elaborate length of pipe, since so soon as the water is turned on the valve commences to pulsate, opening and closing with rapidity, thus reproducing, to perfection, the action of the hydraulic ram. The pump may be operated

* For the illustrations to this item we are indebted to the courtesy of the Editors of the *American Chemist*.—Ed.

with a fall of a few inches of water, instead of 30 feet, as before essential to secure good exhaustion, and to perform its work with great readiness and completeness. Prof. T. E. Thorpe has still further modified the apparatus by constructing the valve of a metallic funnel, perforated with openings. In this funnel is firmly attached a tightly fitting caoutchouc sheet, which operates with the same ease as above, and is much more durable.

Prof. E. A. Smith, of Alabama, who is, as far as our knowledge extends, the first in this country to introduce this improvement, states that its operation is eminently satisfactory, giving, with but a few inches of fall, very good exhaustion.

Lecture Illustrations of Fluorescence.—In a lecture on "Fluorescent Light," recently delivered in the Academy of Music, Philadelphia, President Morton, of Hoboken, exhibited some very remarkable and altogether new experiments.

A large screen, of a pale yellow color, was lowered from the upper regions of the stage, and, as the lecturer expressed it, was interrogated, in the way of experiment, as to what property it possessed, by various colors of light. A brilliant yellow, a green, and a red light, were successively thrown upon it from an electric lamp, but it remained unchanged and made no sign. Then a violet light from the same source, streaming over the word "Fluorescence," flashing out upon the screen in immense letters of luminous green, at once answered the question and illustrated the property. So, again, a gigantic flower, painted in pale monochrome, gleamed out in varied and vivid tints, under a like treatment. In another place, the lecturer alluded to the invisible rays present in the solar beam and light from other sources, which, though inappreciable to the eye, are very active, in photography, and then did what has certainly never before been accomplished—showed these rays, on a fluorescent screen, to the immense audience assembled to hear him. The invisible spectra of copper, silver, zinc, etc., were thus projected and compared.

The substance employed in the superb experiments named above was the new material, Thallene, described in the "Journal" several months ago.

The Oxygen Light.—At the recent Industrial Exhibition of the American Institute, the large hall devoted to this purpose was illuminated upon the plan devised by M. Tessié du Mothay, which has received occasional notices in the "Journal."

Quite recently a brief account of the report of a commission of

experts appointed by the French government was published amongst our items, in which the light was pronounced to be unsuited for street illumination, from the complication of the process and its considerable expense; at the same time, however, it was commended as an excellent one for interior illumination. The results of its trial in the building of the late exhibition seems to have fully confirmed this view of the French experts; since, if we may judge from the enthusiastic comments of the New York press, it has received unlimited praise, from its unusual purity and brilliancy. From the same sources we have it commended as a street illuminant; but, though there can be no question as to its superiority in every quality which an illuminant should possess, we believe that our contemporaries have underrated the objections urged against it for such an application, since in Paris, where it has received an extended trial, it has been removed from the boulevards to give place to the ordinary gas-lamps, which it was designed to substitute.

Government Aid to Science.—In the recent report of the Secretary of War, are contained the following remarks upon the highly important subject of securing government aid in prosecuting an extended series of experiments upon steam-boilers, for the purpose of ascertaining, under the most varied conditions, the cause or causes of explosions, and of determining the remedy:

The universal employment of steam at the present day in naval as well as commercial operations, renders this a matter of extreme interest to all, and one demanding the serious attention of the government. In December last, at the suggestion of private parties who were about to institute some experiments upon actual boilers at Sandy Hook, I appointed a board of engineers to attend and witness the result. Appended hereto is a copy of their report, which seems to indicate that much valuable information and perhaps a solution of the difficult problem may attend a further prosecution of the inquiry. Indeed, the information already acquired is deemed by those competent to judge, of much interest and importance. It is gratifying to know that the experiments which have led to the most reliable information hitherto possessed by the scientific world on this difficult subject, were instituted and conducted by an American institution (the Franklin Institute, of Pennsylvania), under the patronage of our government, over thirty years ago. Those experiments were detailed in two able reports, one made in January, 1836, on the manifestations of steam under various conditions, and its effects, as steam, upon a small model boiler constructed for the purpose; and the other, made some months afterwards on the strength of materials employed in the construction of steam-boilers. The former report was published in Ex. Doc. No. 162, first session, Twenty-fourth Congress; the latter in Ex. Doc. No. 18, second session, Thir-

tieth Congress, included in a special report of the Commissioner of Patents. It is to be regretted that the experiments thus auspiciously commenced had not been continued until a complete solution of the difficulties could have been obtained. No material advance seems to have been made in real knowledge on the subject since that time, and the great desideratum at the present day is a series of well-directed experiments on actual boilers used in navigation.

It was the employment of such boilers in the experiments made last season, at Sandy Hook, which was the means of producing the interesting results before alluded to. But the making of experiments on this scale is attended with too much expense and risk of capital to be carried on by private enterprise. It can only be accomplished under the patronage of the Government, and it seems to me that any reasonable outlay in this direction would be amply repaid in the increased security to our naval and commercial marine Legislative regulation of the inspection and management of steam boilers must necessarily be imperfect under an imperfect knowledge of the causes which lead to explosions; and reliable knowledge can never be attained by silent reflection in the study, or by verbal and theoretical discussion, but only by actual trials on real boilers, under such conditions and circumstances as the present advanced state of engineering science and skill shall dictate. This Department has noticed with much interest that the subject has engaged the attention of Congress, and that a law has passed one House at its late session, providing for a continuation of experiments such as have been recommended. There are few things at this time, affecting the commercial and naval interests of the country, of more practical importance than this, and it is to be hoped that the pressure of business at the coming session will not cause the matter to be overlooked.

Continuous Chlorine Process.—The following is a brief description of a process for this purpose, invented by Tessié du Mothay, which has been the subject of much criticism on the part of our foreign contemporaries. The design of the invention is to manufacture chlorine continuously from a given supply of manganese.

Into a retort containing black oxide of manganese, or a mixture of this substance and lime, and heated to a dark redness, he passes a stream of muriatic acid gas. Chlorine gas and watery vapor are given off, while protoxide of manganese and chloride of calcium remain in the retort. The chlorine may be collected in water if required, or passed into chambers for the preparation of bleaching lime.

Over this remaining mixture in the retort he passes, at the same temperature, a stream of atmospheric air, when the chlorine in the chloride of calcium and chloride of manganese is set free. This stream of chlorine, mixed with atmospheric air, or with variable proportions of nitrogen and oxygen, is led into large stone-ware receivers, containing a mixture of lime and oxide of manganese, previously prepared by decomposing chloride of manganese with an excess of lime

and pouring off the solution of chloride of calcium thus obtained from the oxide of manganese deposited.

In presence of atmospheric air and of chlorine, there is formation of peroxide of manganese and hypochlorous acid, which latter combines with the lime, forming bleaching-lime. This mixture, of hydrated peroxide of manganese, chloride of calcium, and bleaching-lime, is treated with liquid muriatic acid. Thereon chlorine escapes, which is led into the chambers for the preparation of bleaching-lime. In the stone-ware receivers, there remains a mixture of chloride of manganese and chloride of calcium, which is treated afresh with excess of lime, yielding again the above-mentioned mixture of oxide of manganese, lime, and chloride of calcium. The solution of chloride of calcium is run off, the other two ingredients remaining for future operations. By the action of a mixture of atmospheric air and chlorine upon them we again obtain peroxide of manganese, chloride of calcium and chloride of lime.

The chloride of calcium accumulating in these operations is mixed in tanks with carbonate or hydrate of magnesia, when we obtain carbonate of lime (or hydrate) and chloride of magnesium. The latter on distillation gives off hydrochloric acid, which can be again used in the preparation of a further quantity of chlorine. The magnesian residue in the retorts serves for the decomposition of a fresh accumulation of chloride of calcium.

Honor to Inventors.—We have received, through the courtesy of Dr. George Haseltine, of London, the following slip, which is at present going the round of the English press. Its object is so eminently appropriate and deserved, that it will not fail in attracting interest.

"Inventors are a class—*sui generis*—and their rewards, in lifetime, are mostly *nil*, their honors posthumous. They are, moreover, cosmopolitan, and in general their labors, when successful, benefit, not one class or nation alone, but mankind at large.

As it is therefore fitting that, in some shape or form, honor should be given where honor is due, we have learnt with much interest and pleasure that the Commissioners of the New York Central Park have allotted a portion of their domain for the erection of memorials to the inventors of all nations, and it is now proposed to erect one of these memorials in honor of Elias Howe, the inventor of the Sewing Machine.

The good fortune to confer equal benefits on mankind is reserved to few inventors, and while this invention is the world's common inheritance, a large share of the legacy has fallen to Englishmen, who have never yet been found wanting in gratitude to their benefactors. This object appeals directly to the sympathies of the inventive class, of which Mr. Howe was an illustrious representative; and there will, doubtless, besides be many a cheerful giver among the humble users of sewing machines.

The influential committee organised in America to provide the memorial funds will, we learn, be aided by a committee recently formed in this country, which comprises a number of well-known gentlemen, and the co-operation of a number of technical societies has also been obtained. The estimated cost of the memorial is fifty thousand dollars—ten thousand pounds—and a unique design has been submitted to the committee by an eminent sculptor, a personal friend of the inventor. The composition of the committee indicates a very general interest in the movement, and is an earnest of its success. Truly the victories of peace are greater than the victories of war, and the due and fitting recognition and veneration of the heroes of these beneficent victories is at once the ornament and illustration of modern civilization."

Editorial Correspondence.

Dr. Wm. H. Wahl:

Dear Sir,—As your Journal publishes all the scientific novelties, I send you a notice of a curious experiment I saw to-day at our City College. I had called there to see the effect of some suggestions I had made to Dr. Wilkinson (Prof. Doremus' assistant), for deodorizing kerosene oil, and amongst various trials he made the following:

He put a small quantity of permanganate of potash at the bottom of a beaker, then poured in some kerosene, and then added a small quantity of sulphuric acid. Nascent oxygen was immediately generated and *took fire*, with slight explosions as it bubbled through the oil. A little water added seemed to cause a more vigorous display of flashes.

Respectfully yours,

Robt. W. Newberry.

New York City, Nov. 19th, 1872.

Civil and Mechanical Engineering.

TRACTION ENGINES OR ROAD LOCOMOTIVES.*

The Past, the Present and the Future of Steam on the Common Road.

By Professor R. H. Thurston.

When, during the last century, the steam engine had so far been perfected that the possibility of its application to other purposes than the elevation of water had become generally recognized, the problem of its adaptation to the propulsion of carriages was attacked by many engineers and inventors.

As early as 1759, Dr. Robison, who was at the time a graduate of the University of Glasgow, and an applicant for an Assistant Professorship there, and who had made the acquaintance of the instrument maker, James Watts, when visiting the workshop, called the attention of the latter, who was probably then more ignorant of the principles of the steam engine than was the young student, to the possibility of constructing a carriage to be driven by a steam engine, thus, perhaps, setting in operation that train of thoughtful experiment which finally earned for Watt his splendid fame.

In 1765, that singular genius, Dr. Erasmus Darwin, whose celebrity was acquired by speculations in poetry and philosophy as well as in medicine, urged Matthew Boulton, —subsequently Watt's partner, and just then corresponding with our own Franklin in relation to the use of steam power,—to construct a steam carriage or "fiery chariot," as he poetically styled it, and of which he sketched a set of plans.

A young man, named Edgeworth, became interested in the scheme, and, in 1768, published a paper which had secured for him a gold medal from the Society of Arts. In this paper, he proposed railroads on which the carriages were to be drawn by horses, *or by ropes from steam-winding engines.*

These were merely promising schemes, however. The first actual experiment was made, as is supposed, by a French army officer, Nicholas Joseph Cugnot, who, in 1769, built a steam carriage which was set at work in presence of the French Minister of War, the Duke de Choiseul. The funds required by him were furnished by the

* Read before the Polytechnic Club of the American Institute.

Compte de Saxe. Encouraged by the partial success of the first locomotive, Cugnot, in 1770, constructed a second which is still preserved in the '*Conservatoire des Arts et Metiers*,' Paris.

Watt patented a road engine in 1784, after he had made the more essential improvements in general design and in the details of his pumping engine. At about the same time, Murdoch, his efficient lieutenant, completed and made a trial of a model locomotive, driven by a "grasshopper engine," having a steam cylinder three-quarters of an inch in diameter and two inches stroke of piston. It is reported to have run six to eight miles an hour, its little driving wheels making from two hundred to two hundred and seventy-five revolutions per minute.

In 1786, Oliver Evans asked of the Pennsylvania Legislature the monopoly of his method of applying the steam engine in driving flour mills *and to propelling wagons*. In the same or following year, Wm. Symington constructed a working model of a steam carriage, which may still be seen in the Patent Museum at South Kensington, London.

In 1802, Trevithick and Vivian took out a British patent for a locomotive engine, and their model is also preserved in the Museum of the British Patent Office.

In 1804, Oliver Evans completed a flat-bottomed boat to be used at the Philadelphia docks, and, mounting it on wheels, drove it by its own steam engine to the river bank. Launching the craft, he propelled it down the river, using its steam engine to drive its paddle-wheels. Evans' "*Oructor Amphibolis*," as he named the odd machine, was the first road locomotive that we find described after Cugnot's time.

Evans assured incredulous legislators that carriages propelled by steam would soon be in common use, and offered a wager of three hundred dollars that he could build a "steam wagon" that should excel in speed the swiftest horse that could be matched against it.

In 1821, Julius Griffiths of Middlesex, England, made a steam carriage for common roads, which he designed to carry passengers, and which was probably the first ever constructed for that purpose only.

During the succeeding ten or fifteen years, Messrs. Burstall & Hill of London and Edinburgh, Mr. Goldsworthy Gurney, the Messrs. Seaward, W. H. James, Walter Hancock, Ogle & Summers, Sir Chas. Dance, and others in Great Britain, and Harrison Dyer, Joseph Dixon, Rufus Porter and a Mr. James, in the United States, with, probably, many others whose names are unknown in history, attacked this important and seductive problem with varying success.

In December, 1833, about twenty steam carriages and traction road engines were running, or were in course of construction in and near London.

In our own country, the roughness of roads discouraged inventors, and, in Great Britain even, the successful introduction of road locomotives, which seemed at one time almost an accomplished fact, finally met with so many obstacles that even Hancock, the most ingenious, persistent and successful constructor, gave up in despair. Hostile legislation procured by opposing interests and, possibly also, the rapid progress of steam locomotion on railroads caused this result.

In consequence of this interruption of experiment, almost nothing was done during the succeeding quarter of a century, and it is only within a few years that anything like a business success has been founded upon the construction of road locomotives, although the scheme seems to have been at no time entirely given up.

J. Scott Russell, Boydell, and a few others in England, and Messrs. Roper, Dudgeon, Fawkes, Latta, and J. K. Fisher, in the United States, have all, at various times labored in this direction.

The last-named engineer designed his first steam carriage in 1840, and is still at work.

Abroad, a few firms have succeeded, within a few years past, in making a business of considerable extent in constructing road locomotives for hauling heavy loads, and in building steam road rollers.

While steam carriages of high speed, and adapted to the transportation of passengers, have not yet been successfully introduced, a most promising start has been made in the application of steam to the heaver kinds of work on the common road.

The great impediments seem to be the roughness and bad construction of the ordinary highway, the damages arising from the taking fright of horses, the engineering difficulties of construction and the limited power of the machine as it has usually been built. Hostile legislation might perhaps be placed in the category, but we are probably sufficiently far advanced in civilization to-day to be able to secure liberal legislation when the people shall be satisfied that the introduction of the road locomotive will be of great public advantage.

The capabilities of the road locomotive are readily determined by experiment, and the following paper embodies the results of several series of trials.

When in Great Britain, some two years ago, the writer found that

the construction of traction engines and steam road rollers was occupying the attention, to a considerable degree, of several engineering firms, among whom may be mentioned Messrs. Aveling & Porter, Tuxford & Sons, Burrell, Ransomes Sims & Head and others.—Messrs. Fowler & Co. were constructing machines to be used in steam ploughing, an application of steam to which they were giving especial attention.

The first-named firm seemed a leading one in the business of building road locomotives, and about 400 workmen were kept employed by them. Their engines seemed well built and had an excellent reputation, but, unfortunately, the short time available merely permitted an inspection of their machines, and no opportunity offered to witness a prearranged trial, or even to see them at ordinary work.

More than two years previous to the period just referred to, a trial of these machines was made by the well known French engineer, Mon. H. Tresca. *Sous-directeur du Conservatoire Imperial des Arts et Metiers*, Paris, and in presence of the equally distinguished English Professor, Fleemin Jenkin. The report was submitted to the *Directeur*, General Morin, January 15th, 1868.*

The results may be summarized as follows:

1. The coëfficient of traction was determined to be about 0·25 on a good road with easy grades.

2. The consumption of coal was found to be 4·4 pounds per horse-power per hour.

3. The consumption of water was determined to be 132·2 gallons an hour with the "ten-horse" engine.

4. The "coëfficient of adherence," or of friction between the wheels and the soil was 0·3.

5. A rate of motion of seven miles an hour produced no special difficulty in managing either the locomotive or its load.

This engine was of large size, having a steam cylinder of 11 inches diameter and a stroke of piston 14 inches. The crank shaft was geared to the driving-wheels in such manner as to make 20·33 or 14·25 revolutions, at pleasure, for each revolution of the drivers. The driving-wheels were 6½ feet in diameter, and the weight of the machine, exclusive of fuel and water in its tank, was fourteen and one-half tons. Including fuel and water its weight was seventeen

* *Proces-verbal des Experiences faites sur une machine de traction; Conservatoire des Arts et Metiers;* Paris; 1868.

and one-half tons. The load drawn on a level road was 79 tons, 19 cwt., 1 qr., (77,597 kilo's), including the weight of the machine itself.

This weight was distributed as follows:

Weight of engine,	. .	21·8 *per centum*	of total.
" wagons,	. .	25·9 "	"
" paying load,	.	52·3 "	"
		100·	

In addenda to the report of M. Tresca it is stated that M. Lalouette had set the engine at work transporting heavy material, and with the following results:

It transported a total weight of 2,500,000 kilogrammes a distance of 4 kilometres, drawing, on each trip, 25,000 kilogrammes of paying load, and making four trips per day. Five hundred kilogrammes of coal were consumed in eight journeys.

At about this same time, M. Servel, *Ingenieur en chef de la Compagnie Générale des Messageries à Vapeur*, conducted a series of experiments with a similar machine upon paved and upon macadamized roads, during what he describes as the most trying of winter weather. Under such unfavorable conditions, M. Servel reports the following distribution of weights by *per centum*:

Weight of locomotives,	. . .	41.4
" wagons,	. . .	18·2
" paying load,	. . .	40·4
		100·

The average total weight of three loaded wagons, which was the usual load, was 22,575 kilogrammes, or very nearly 22 tons.

The experiment was made in 1867—'8 of applying these engines to the towage of boats on the French canals. The results seem to have been very encouraging. M. Géraldi reported that an 8-horse engine towed on the canal between Caen and Oyestreham, a fleet, having an aggregate measure of 800 tons, at the rate of three miles an hour, and that the speed had been pushed, on occasion, up to six miles an hour. The latter speed was not considered an advisable one, however.

M. Carfort reported to M. Huet that a 6-horse engine, doing similar work on the Dunkerque and Saint Omer canal, had towed 800 tons and was regularly towing 500 to 700 tons at an expense not exceeding 40 per centum of the cost of horse power.

In the year 1871 a number of traction engines were exhibited before the Royal Agricultural Society of England at their show at Wolverhampton, and the judges appointed by the Society made a series of exceedingly interesting and instructive tests.*

The judges state in their report that on a road in good order wheels fitted with India-rubber tires, as patented by Thompson, have an advantage over iron rigid wheels in tractive force, but that the cost of such wheels—fifty per centum of the cost of the locomotive—forms a most serious obstacle to their adoption; still they "are not prepared to express a decided opinion" upon that subject. On farm roads and in fields the India-rubber tires "signally failed." Plain iron wheels, with "paddles" attached, succeeded where the former failed.

A 10-horse locomotive entered by Messrs. Aveling & Porter received the first prize at the termination of these trials; two competing systems of rubber tires—those of Thompson and of Adams—were each awarded a silver medal; a 6-horse power road locomotive by Aveling & Porter, and an 8-horse power road engine by Burrell, were very highly commended.

The prize engine had a cylinder of 10 inches diameter and a stroke of piston of 12 inches, a fire grate area of 6½ square feet, an area of heating surface of 204·4 feet, driving-wheels 6 feet in diameter, and 18 inches breadth of face. These wheels made one revolution to 17 of the crank shaft. The total weight of the engine was 12 tons, of which 8¾ were on the driving-wheels. The coal used, on special trial, amounted to 3·2 pounds per indicated horse power per hour, and the evaporation of water was 7·62 pounds per pound of coal consumed, the average temperature of feed being 175° Fahrenheit.

The load drawn up the maximum grade of 264 feet to the mile on Tottenham hill, which is 1900 feet from top to bottom, was 26 tons, or, including weight of engine, 38 tons, giving a coefficient of traction of 0·35.

On a country road, 16 miles long, it drew 15 tons at an average rate of speed of 3¾ miles per hour, using 2·85 pounds of coal and 1·94 gallons of water per ton of useful load per mile.

On farm soil, soaked with recent rains, the load drawn was 9 tons, and speed something less than an average of two miles per hour, using 13·6 pounds of coal per ton of paying load per mile. This engine was fitted with smooth-tired driving-wheels.

* Journal of the Royal Agricultural Society of England, Vol. VII; London: J. Murray, 1871.

In July, 1871, another trial was made in the same vicinity at the request of officials of the British War Department, during which a 6-horse engine, by the same builders, drew 7 tons, 12 cwt., up a hill having a maximum grade of one in 7·33, or more than 600 feet to the mile.*

In September of the same year still another trial of the same, or a duplicate engine, occurred between Rochester and Chatham, in which the same style of driving-wheel was used as in the trials at South Orange, N. J., to be hereafter described.

Star Hill was ascended by this engine, the maximum grade being 480 feet to the mile. This performance is compared by *Engineering* with that of a road steamer fitted with India-rubber tires, which was tried earlier at Tettenham. The first named engine drew 2·94 times its own weight, and its competitor hauled 2·5 times its weight on maximum grades of 1 in 11 and 1 in 18, respectively—excellent performances both. The rigid wheel in this case seems to have had considerably greater pulling power than that fitted with elastic tires.

The authorities already quoted furnish valuable information as to the capabilities of this system, but the writer, in common with many others of the profession, has long been desirous of learning more of its value on good roads by personal observation. Fully believing in the ultimate and general adoption of steam traction on our streets and roads, it yet seemed a question whether there might not exist some unanticipated obstruction, or some serious difficulty not referred to in published reports.

The desired opportunity recently presented itself when the writer was requested to conduct a public trial of the road locomotives of Messrs. Aveling & Porter, and of their steam road rollers, and was proffered every desired facility for making a thorough examination of the construction of the machines, and for testing their powers of traction and manœuvring. Mr. W. C. Oastler, agent for the builders, promised to furnish one locomotive, and Mr. Daniel Brennan, Jr., President of the Telford Pavement Co., of Orange, N. J., offered a road locomotive and a steam roller, with the privilege of taking as a trial ground any portion of the macadamized road which the company were constructing at South Orange.

Engagements permitting, a day, Saturday, September 21st, was taken for a visit to Orange to inspect the engines and to select a trial ground. The trial was to take place October 1st, and invitations were

* London Engineering, July 14, 1871.

extended to and accepted by the Commissioners of Public Roads for Essex and for other Counties of New Jersey, and by many well-known engineers of New York and vicinity.

Two road steamers or traction engines and a steam road roller were brought out for exhibition and trial.

No. 1 was a new road locomotive built by Messrs. Aveling & Porter it had previously done no real work. A sketch of this machine is shown in Figure 1.

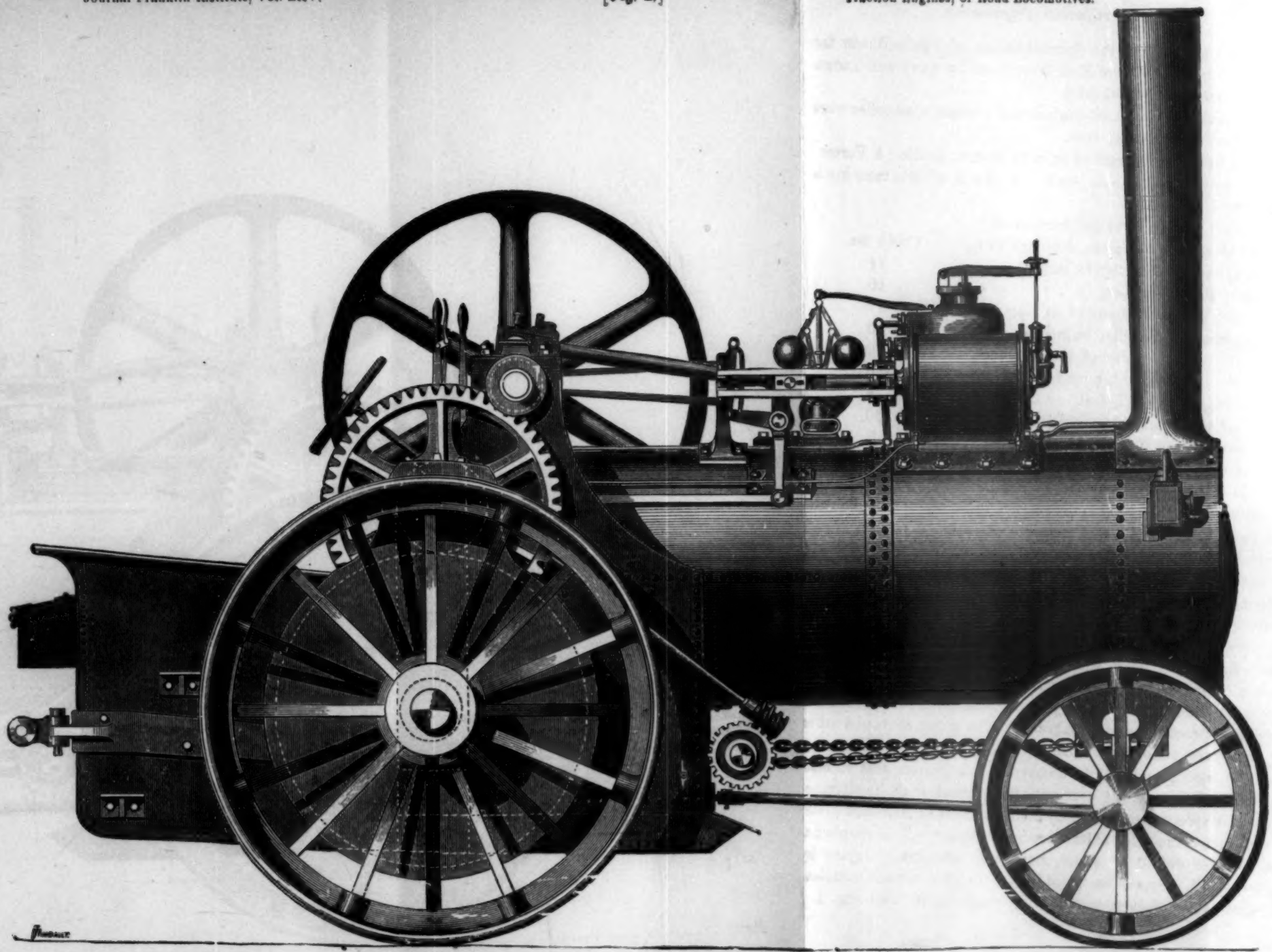
The following are the principal dimensions:

Weight of engine, complete, 5 tons, 4 cwt.,	11648 lbs.
Steam cylinder—diameter in inches,	7¼.
Stroke of piston—inches,	10.
Revolution of crank to one of driving-wheels,	17.
Driving-wheels—diameter in inches,	60.
" —breadth of tire in inches,	10.
" —weight, pounds each,	450.
Boiler—length over all, feet,	8.
" —diameter of shell, inches,	30.
" —thickness of shell, inches,	7/16.
" —firebox sheets, outside, thickness in inches,	½.
Load on driving-wheels, 4 tons, 10 cwt., pounds,	10,080.

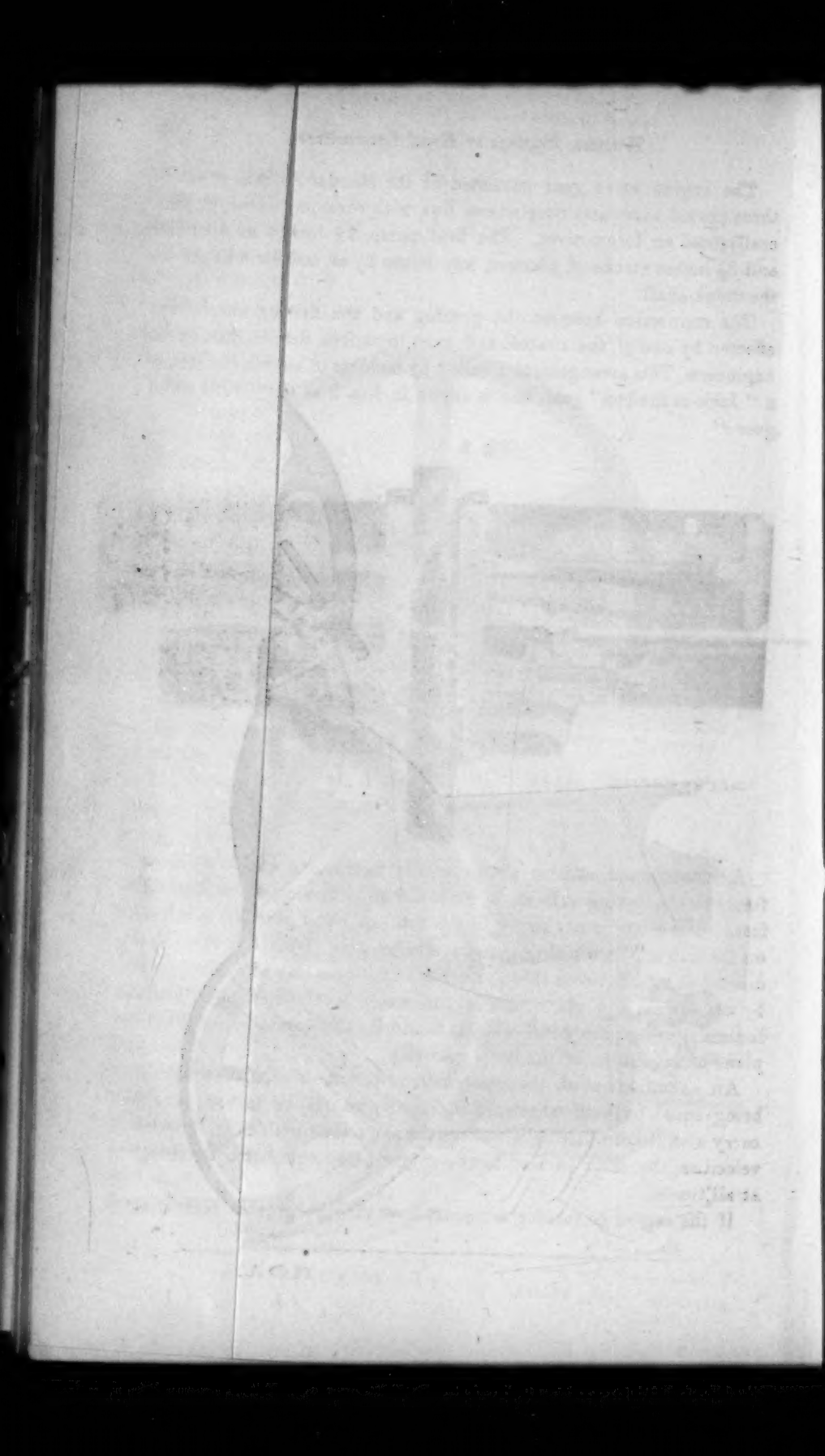
The boiler was of the ordinary locomotive type, and the engine was mounted upon it, as is usual with portable engines.

The driving pinion on the crank shaft was made capable of being slipped out of gear, thus allowing the engine to be kept in motion when the locomotive was at rest, either to pump water into the boiler or to drive as a "portable engine," by a belt which could be carried on the pulley, 4½ feet in diameter and 5 inches face, which was fitted to act as a fly-wheel. When used as a "portable engine," regulation was effected by means of a fly ball governor conveniently attached.

The steam cylinder was steam jacketted in accordance with the most advanced practice here and abroad. The crank shaft and other wrought iron parts subjected to heavy strains were made of Lowmoor iron and were strong and plainly finished. The gearing was of malleableized cast iron, and all bearings, from crank-shaft to driving-wheel, on each side, were carried by a single sheet of half-inch plate, which also formed the sides of the fire-box exterior. This simple but admirable device united all parts, peculiarly exposed to injury by jarring, with such firmness as would seem to give almost absolute security against such injury on even very rough roads. See Fig. 1.



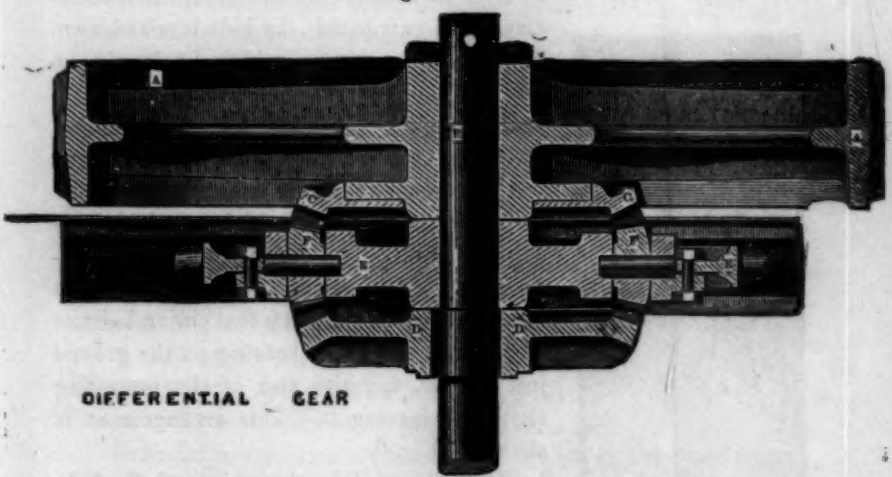
ROAD LOCOMOTIVE—Built by Aveling & Porter.



The engine valve gear consisted of the standard arrangement of three ported valve and Stephenson link with reversing lever, so generally used on locomotives. The feed pump, $1\frac{3}{4}$ inches in diameter and $3\frac{1}{2}$ inches stroke of plunger, was driven by an eccentric keyed on the crank-shaft.

The connection between the gearing and the driving-wheels was effected by one of the neatest and most ingenious devices known to engineers. This arrangement is called by builders of cotton machinery a "Jack-in-the-box" gear, and is shown in Fig. 2 as the "differential gear:"

Fig. 2.



As constructed, and as shown in the figure, one wheel (A) turns freely on the driving-axle at B, while the other driving wheel is keyed fast. The latter is not shown in the cut. A bevel gear (C) is bolted on the hub of the wheel (A), and a similar gear (D) is keyed to the driving-axle. Between these revolves a spur gear (E), which is driven by the engine, and which carries two small bevel pinions (FF), the latter engaging both bevel wheels, C and D, their axles being in the plane of revolution of the large gear (E).

An examination of the combination will show that, resistances being equal on both wheels, if the spur gear (E) be turned, it will carry with it both driving-wheels at the same time with equal angular velocities, the effort exerted by the engine being equal at both wheels at all times.

If the engine be turning a corner, however, the greater resistance

on the inside wheel retards that, while the outer wheel necessarily moves more rapidly over its longer path, and, while the engine still exerts the same force on both wheels, the work done is distributed unequally between them through the then revolving bevel pinions, without loss and without either wheel being necessarily slipped or disengaged. Should one wheel, however, strike into a soft spot, as a patch of muddy soil, and finding so little resistance as to turn freely, leaving the opposite wheel at rest on firmer soil and thus checking the motion of the locomotive, a heavy bolt, which is furnished with each machine ready fitted to its place, is inserted and keys the loose wheel to the shaft. Both wheels must then turn together until, the locomotive being extricated, the bolt is withdrawn. Such an occurrence is seldom likely to take place.

The driving-wheels were of wrought iron, strong but light in their construction, and were fitted with strips of iron, thickest at the middle of their lengths, which were laid diagonally across the face of the wheels, with separating spaces of about two inches between them. The angle was such that one end of one strip would come to a bearing on the ground just as the opposite end of the preceding strip was leaving it. This arrangement is shown in Fig. 3.

The builders claim that this method of obtaining tractive power in the wheel gives the engine a pulling power, on good ground, equal to 0.45 of the insistent weight,* while, with the smooth wheel used in the trial described in the report to the Royal Agricultural Society, quoted above, that coëfficient is but 0·25.

☞ On extremely hard and smooth roads, bolts may be inserted in the wheel rim, whose heads give better holding power than even these

*This is equal to that obtained with the India-rubber tired wheel at Wolverhampton. A committee of the Royal (British) Engineers, consisting of Colonels Gallway, Wray and Lennox and Captain Home, compared the pulling power of these wheels with that of India-rubber tired wheels in November, 1870, using the same engine with both, on Star Hill, near Rochester. They found them to be equal, with equal insistent weights.

The writer regrets that he has no personal experience with which to compare these results.

iron strips, and on very soft ground the same bolts are used to secure to the rim of the wheel pieces of angle iron, called by the builders "paddles," which take a good hold upon on the more unstable kinds of soil.

The weight of this locomotive rested principally upon the driving-wheels; about fifteen per centum was left upon the forward axle to insure good steering power.

The total weight on the drivers was somewhat increased when pulling a load, usually, by the inclination of the line of traction downward from the pulling bolt to the point of attachment to the load.

The forward axle is fitted with wheels of 42 inches diameter and 8 inches face; it swings about a king-bolt which is secured above in a bracket secured to the under side of the boiler smoke-box and is steadied by a strong rod, connecting its lower end with the forward end of the fire-box.

Chains led from each end of the axle to a shaft carried on the forward end of the fire-box, around which they wound in such a manner that turning this shaft would swing the axle.

A hand steering wheel, conveniently arranged near the throttle and reversing handles, turned this shaft, being connected with it by means of a worm shaft and pinion.

A tank at the rear of the locomotive carried coal and water in its compartments, and afforded a standing place for the engine driver from which he could readily reach the various handles and guages.

Draught was secured by means of the exhaust, and, when desired, the latter could be turned into the water tank, thereby securing a double advantage, heating the feed water and rendering the engine noiseless.

The boiler and steam cylinder were both well protected against losses of heat by coverings of felt and lagging.

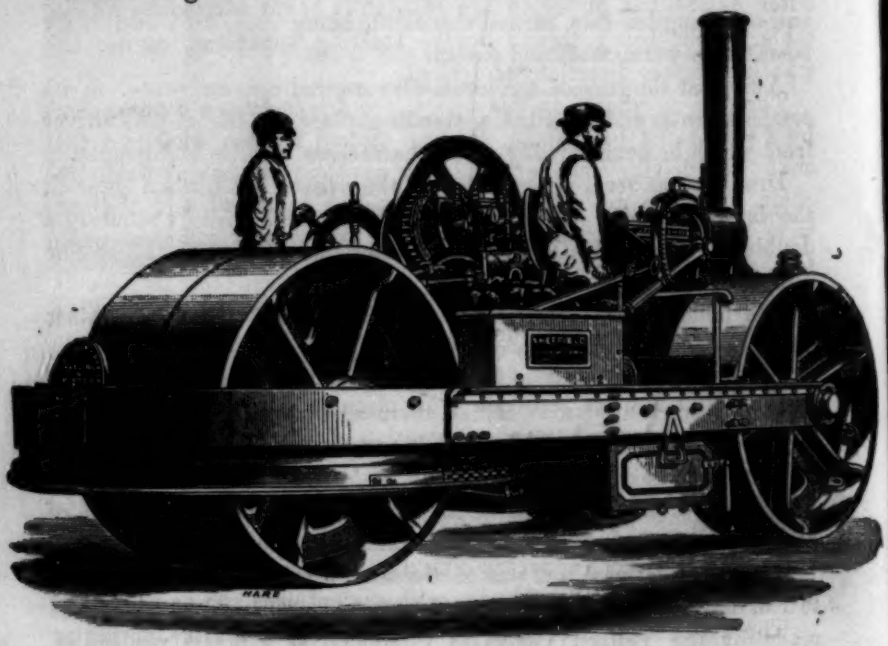
No springs were used on the engines exhibited as, being intended for heavy work at slow velocities, their advantages would not, it was supposed by the builders, justify the expense and complication attending their use.

A strap brake was fitted on the driving axle for the purpose of controlling the engine on heavy grades.

Road locomotive No. 2 was of the same size and of similar make to No. 1. It had been two years in use, or longer, on the roads made by the Telford Pavement Company, as a steam road-roller. To convert it into a road-roller, its ordinary driving-wheels had

been removed, and, in their place, were fitted a pair of cast-iron wheels, of similar diameter, but of 20 inches breadth of face, and weighing 3,800 pounds each. Their faces were left smooth, as hauling power was not desired, and as it was intended that they should leave the surface of the road as smooth and as firmly compacted as possible. In these driving-wheels, the engine carried an excess of weight of 6,700 pounds as compared with No. 1. In statements of work done, this excess should be entered as a part of the paying load where No. 2 is employed as a traction engine. The great weight of these wheels has an important effect in preventing the liability of slipping, which is a consequence of their smooth surface, and should bring up the equivalent coëfficient of adherence, in terms of the original weight of the engine, to about 0·42, or nearly equal to that of No. 1 with its regular traction wheels. As, during the trials about to be described, no slip was in any case observable, this difference would not in any way affect the results.

The weight of the steam road-roller offered for trial, everything included, was fifteen tons, or 33,600 pounds. This machine is represented in Fig. 4.



The engine and boiler were of the same general dimensions as the road locomotives already described. The furnace door was placed at one side of the fire-box, and the reversing lever, throttle handle and steam gauge were all brought to the same side, the engine driver standing on the frame of the machine, which is sufficiently broad and is immensely strong. The tanks for fuel and water were so placed as to be within reach of the driver. The steering apparatus was located at the side opposite the working gear of the engine, and was operated by the engine driver's assistant, who finds standing room on that side. The whole machine was carried on four large wheels, with broad tread, covering a total width of six feet. Its weight exerts a compressive force of 5,600 pounds on each foot of width, or 467 pounds on each inch.

The wheels had holes drilled in their faces, like the wheels of the traction engines, in which could be inserted strong spikes for breaking up old roads previous to making repairs, or for loosening the surface previous to metalling new roads.

Referring to Fig. 4, it will be noticed that the steering wheels are set close together, at the fire-box end of the machine, on an axle, the outer extremities of which are secured in boxes carried by a turntable. This, being turned by the steering apparatus, carries the wheels in either direction, as desired.

The driving wheels, in this design, are driven from a counter shaft by a strong flat link chain, leading around a chain wheel on that shaft, and driving a similar but larger wheel on the driving axle. The chain links are made of forged scrap, case hardened, and the pins were of steel. A brake on the driving axle was of sufficient power to control the roller on the heaviest grades.

The whole machine was evidently well proportioned, and of great strength and simplicity in details.

PRELIMINARIES.—The preliminary examination of the proposed trial ground and its selection took place late in September, and a half day was devoted to an examination of the engines and of the road-bed. Engine No. 1 was found at Orange, and, after a careful examination had been made of its design and construction, the driver started with it over an awkwardly narrow and winding piece of road, traversing it without apparent difficulty, and going forward and backward at varying speeds, steering with evident ease and accuracy.

The writer then took the place of the driver, and, although the experience was a novel one, found no difficulty in acquiring, in a very

short time, such command of the machine that it became evident that but little training would be required to enable any ordinarily intelligent mechanic to manœuvre the locomotive on the most difficult road. The reversing handle, the throttle and the steering wheel were conveniently located and easily operated. Reversing could be performed promptly, notwithstanding the weight and consequent momentum of the fly-wheel, which, it had been apprehended, might cause loss of time, if not an excessive strain, when reversing suddenly. Steerage seemed almost equally easy and precise, whether going forward or backward. A block of wood, six or eight inches high, thrown under one forward wheel, was driven over without apparent difficulty or injury to the machine.

After these experiments and the examination of the locomotive were concluded, the party rode over to South Orange, where a portion of road containing heavy grades was selected for the public trial of the locomotives which have been described. It consisted of a short section of nearly level road, A A′ (Fig. 5), in the village of South Orange, near the railroad station, and of that part of the road, on either side of this nearly level stretch, which ascends from the valley by a moderately heavy grade, A E, on the eastern side, and by a very remarkably steep grade, A′ W, on the western side. The profile, as given, was kindly furnished by the county engineer, Mr. Jas. Owen, of Newark, N. J.

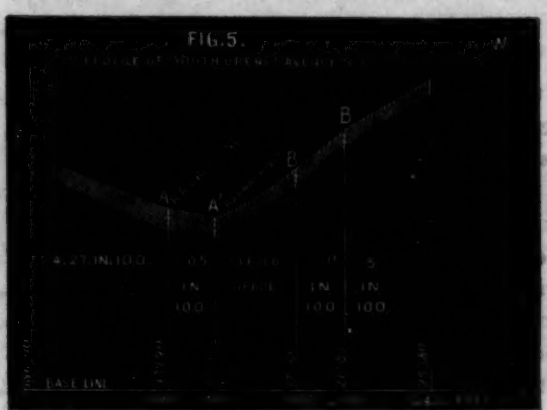


FIG. 5.

This forms a portion of some fourteen miles of macadamized road, completed, during the past season, by the Telford Pavement Co., to whom No. 2 locomotive and the steam roller belonged.

The road-bed was remarkably smooth, hard and compact. It was constructed in the following manner: The original surface of the old road was first ploughed up and levelled off, the ploughing being done

by an immense plough, built for that purpose, and designed to be drawn by the road locomotive owned by the Pavement Company.

The surface is next carefully levelled up and brought to the required form, and is well rolled by the steam road-roller. The bed is then ready for the metalling. This consists of fragments of the very hard trap rock which lines the western bank of the Hudson river, near New York, and forms the Palisades, extending back from the river into the State of New Jersey.

The quarry is situated a short distance from the South Orange Railroad station, the county road leading directly past it. Steam drills are employed in holing, and the masses broken down by the blast are reduced by the quarrymen to a size which allows them to enter between the jaws of two Blake stone crushers, which are kept constantly at work preparing broken stone for the road. The whole plant is well placed and well arranged, and exhibits many interesting features which cannot be described here.

The heavier fragments are separated, by means of revolving screens, from the finer pieces and are used in forming the first layer of metalling. These heavy fragments, measuring from four to eight inches in their longest dimensions, are placed by hand, and the workmen settle them well in their place by striking them with a moderately heavy hammer.

Another layer of smaller material is used to cover that first laid down, and, upon this the steam road-roller is used until it is well compacted. As still finer material is added, the rolling is repeated until the surface becomes wonderfully hard and smooth. As a matter of course it must be extremely durable, even under heavy traffic. The trap rock used as metalling is one of the finest kinds of material to be found in our own or any other country, and the method of working it, here adopted, seems to be well adapted to securing the best results with it.

Such remarkably fine roads are, unfortunately, too seldom seen in this country, although not unfrequently met with in Great Britain and on the Continent of Europe. The fact is due partly, no doubt, to the infrequency of occurrence of such excellent material for metalling, but principally arises from the circumstance that very few boards of road commissioners are sufficiently interested in their work, and, at the same time, sufficiently energetic and far-sighted to indulge in what often seems extravagant expenditure, but what is really one of the most important among the means available for economizing greatly the cost of local and suburban transportation.

The road selected for the trials had been just made in the manner above described and seemed in excellent order, although the president of the company considered that it required considerably more rolling to make it what it was intended to be and in accordance with his specifications.

The trials were planned, and September 27th was the date fixed for them. That day proving stormy, they finally took place October 1st, in presence of a large number of gentlemen interested, professionally or otherwise, in the subject. The log was kept by student J. A. Henderson, of the class of 1873, Stevens Institute of Technology, to whose intelligence and zealous interest the writer is greatly indebted for the completeness of the record, as well as its accuracy.

First Trial.—The first trial was made at 10 o'clock, A. M., Oct. 1st, with Engine No. 1.

The load consisted of two wagons heavily laden with stone, and weighing, with their loads, 5000 and 5600 pounds, respectively—a total of 10600 pounds.

This load was drawn up a grade of 10·10 in 100—B. B. Fig. 5—equal to 533·28 feet per mile.

The wagon tires were very narrow and much worn, and were observed to cut into the roads somewhat, notwithstanding the thoroughness with which the road-roller had done its work.

The driver of the engine was a lad without experience. By putting coal in large pieces on his fire, at the worst portion of his route, he caused his steam pressure to fall rapidly, and was compelled to stop on the heavy grade until the pressure rose to 90 pounds again, when another start was made, and the top of the hill was reached without apparent difficulty.

Some annoyance was experienced from priming, partly in consequence of the low pressure maintained in the boiler, but principally, no doubt, because the boiler had not been in use long enough to thoroughly clean its interior surfaces. This engine was, therefore, detached, and No. 2, which had been long in use, was taken for the next trial over this same course.

Second Trial.—A trial was next made of the power of manœuvering possessed by these engines.

No. 1 was stationed at a part of the road which had not been rebuilt, and where the ground was soft and uneven. The machine turned *continuously* for a considerably time, in a circle of 18 feet radius, crossing the gutter at one part of the course, and gave no

evidence of difficulty arising from any cause. The engine could turn, when required, in a space slightly greater than its own length by carefully backing and filling.

THIRD TRIAL.—Locomotive No. 2, being attached to the same two wagons used in the first place, drew them up the hill to the summit without halting, and without priming or difficulty of any kind. The steam gauge indicated, at starting, 120 pounds, and at stopping, 90 pounds pressure of steam.

The time occupied in traversing 1450 feet was 3½ minutes; the speed being about 4¼ miles per hour. Returning to the foot of the hill, a third wagon was brought up and attached, with the other two, to the same locomotive.

FOURTH TRIAL.—The total load in wagons was now 16530 pounds, and the excess in weight of the rolling wheels of this engine over the regular and, as already stated, more efficient traction driving wheels of No. 1, brought up the figure to a total of 23230 pounds.

This load was taken up the same heavy grade in four minutes,—almost precisely four miles an hour. The steam pressure varied from 105 to 120 pounds.

The action of the driving wheels was carefully observed, but no evidence of slip could be discovered, with even this last heavy load.

The proprietor and agent both desired to try again, using the same engine, with a fourth wagon added to the train, but time was passing rapidly and it was decided to change the ground, and to experiment with heavier loads on less exceptional grades.

FIFTH TRIAL.—The locomotives and wagons were taken across the railroad track to the other portion of the selected road—A, E, Fig. 5—where the grade was 4·27 feet rise in 100 of horizontal distance, or 225·46 feet per mile. This did not approach, in steepness, that already described, but it was, nevertheless, a heavy grade.

Engine No. 1 was here attached to a train of six loaded wagons, weighing, all together, 34080 pounds. Starting with 95 pounds of steam, it drew the train steadily, and with apparent ease, except when, as in the first trial, priming occasionally produced some annoyance.

SIXTH TRIAL.—The train was stopped, engine No. 2 was substituted for No. 1, and, with the same load, on the same grade, a trial of speed was made. The mean speed, over the whole course, was 3·6 miles per hour, that figure being somewhat exceeded at times.

The steam pressure varied between 90 and 105 pounds. The length of the course was 1435 feet.

SEVENTH AND LAST TRIAL.—A train of ten wagons was next made up, and engine No. 2 was attached. The total load was now 63400 *pounds;* the course was the same as during the preceding trial. Several unsuccessful attempts were made to start this load, the connecting chains snapping as soon as the strain came fully upon them. Chains were finally obtained of sufficient strength, and a start was made. The load, increased by the weight of a large number of men and boys who clustered upon the wagons, was taken to the top of the hill without accident and without a halt. The steam pressure varied between 85 and 124 pounds per square inch. At the lower pressure, the throttle was carried full open, and it was evident that all the steam that the engine would take was required to keep the piston moving. At starting, the engine exhibited a tendency to rise forward. It may be concluded from these two facts that this load was about a maximum for the engine when carrying 85 pounds of steam, and that, while drawing it, nearly all the weight of the engine was brought upon the drivers.

Even during this trial no slip of the driving-wheels could be detected, notwithstanding the fact, already stated, that they were smooth on their wearing surfaces. The marks left, by the bolt holes in their rims, upon the surface of the road were perfectly distinct and undistorted. The engine gave no trouble by priming.

It was noted, during the trials on this grade, that the wagons would just start backward down the hill when detached, and it is therefore to be concluded that the coëfficient of traction on a level, corresponding with the coëfficient of rolling resistance, must have been very nearly represented by the tangent of the angle of the grade, or about 0·0427 ; it may be assumed at 0·04.

Coal.—The amount of coal used on this engine during the day was 350 pounds.

Effect on the Road-bed.—During all trials, the effect produced by the locomotive upon the road surface was carefully observed and compared with that produced by the hoofs of the horses, which were at intervals climbing the second grade with loaded wagons similar to those used with the traction engine. The hoofs of the horses, it was noticed, cut into the road somewhat, loosening the metalling and injuring the surface, thus increasing the resistance offered to the vehicles following them. The wheels of the traction engine, on the con-

trary, very perceptibly compacted and improved the road, and thus, to some extent, reduced tractional resistances. There was a marked difference in the action of the two motors upon the surface, and it was evidently a matter of economical importance.

Horses vs. Steam.—Each wagon could usually be drawn to the top of the hill by two good horses, but only with very great effort. Three were required to do the work as comfortably as it should be done, and this number could pull a single load steadily and with moderate exertion.

The locomotive on this grade therefore performed the work of between twenty and thirty horses. We may conclude that it can, with 85 pounds of steam, draw a load which would require the severest exertion of twenty horses. The maximum steam pressure proposed by the builders of these engines is 130 pounds, at which pressure they are still far below the limit allowed by our own laws.

It was now late in the afternoon, and it was concluded to suspend work for lack of time to make up other trains.

The great steam road-roller was brought forward; its construction was examined by all present, and its effective action in compacting the road was observed. It moved backward and forward, on this grade of 225 feet to the mile, rapidly and steadily, and was said by its owner to be able to ascend the grade of 533 feet to the mile, upon which the first trial was made with the traction engine.

The day's work thus terminated and the party separated. The information which had been acquired respecting steam traction and the construction of metalled roads was most valuable, and it was considered by all that the day had been spent pleasantly and profitably.

Résumé.

Reviewing the experiments on the Aveling & Porter road locomotives and steam road-roller, we may make a brief *résumé* of the facts developed, thus:

1. A traction engine may be so constructed as to be capable of being easily and rapidly manœuvred on the common road and in the midst of any ordinary obstructions.

2. Such an engine may be placed in the hands of the average mechanic, or even of an intelligent youth of 16*, with confidence that he will quickly acquire, under instruction, the requisite knowledge and skill in its preservation and management.

* The manufacturers state that one of their most skillful drivers, at Wolverhampton, was a boy of 14.

3. An engine weighing rather more than five tons may be turned continuously in a circle of eighteen feet radius without difficulty and without slipping either driving wheel, even on rough ground, and may be turned in a roadway of a width but slightly greater than the length of the locomotive, by proper manœuvering.

4. A road locomotive, weighing 5 tons, 4 cwt., has been constructed, which is capable of drawing, on a good road, more than 23,000 pounds up the almost unexampled grade of 533 feet to the mile at the rate of four miles an hour.

5. Such a locomotive may be made, under similar conditions, to draw a load of more than 63,000 pounds up a hill rising 225 feet to the mile, at the rate of two miles per hour, doing the work of more than twenty horses.

6. The action of the traction engine upon the road is beneficial, even when exerting its maximum power, while, with horses, the injury to the road-bed is very noticeable.

7. The coëfficient of traction is, with such heavily laden and roughly made wagons as were used at South Orange, and under the circumstances noted, not far from *four per centum* on a well made macadamized road.

8. The amount of fuel, of good quality, used may be reckoned at less than 500 pounds per day, where the engine is a considerable portion of the time heavily loaded, and, during the remaining time, running light. It may be considered, without probability of serious error, that, during the trials at South Orange, Engine No. 2 performed pretty nearly an average day's work.

Deductions.—A number of interesting problems may be solved by reference to the facts learned here. A comparison of the efficiency of the road steam traction engine with that of horse-power, in drawing heavy loads, is especially important, and we will now make such a comparison, basing it upon the most reliable data at hand.

Traction Force.—It has been already stated that Engine No. 2 developed a tractive force equal to that of twenty horses.

The actual tractive force may be determined as follows:—The coëfficient of traction was, as has been shown, not far from 0·0427, which is also very nearly the maximum figure given by General Morin, as determined by his experiments with "dray-carts" and "*chariot-porte-corps d'artillerie*," upon metalled roads and upon roads paved with sandstone.* This coëfficient is large, partly in conse-

* Morin's Mechanics: New York, D. Appleton & Co. 1860, p, 348.

quence of the very slight breadth of the wheel tires and the small diameter of the wheels of the wagons used, and partly because the wagon bodies were not mounted on springs. To be absolutely certain that no error is committed by over-estimation in the following calculation, this coëfficient will be taken at 0·03.

The actual tractive force required to overcome the rolling resistance was, then, $63{,}400 \times 0{\cdot}03 = 1902$ lbs. The force required to overcome that component of the force of gravity which directly resisted the motion of the load, in this case, where the road laid at an angle with the horizontal, whose tangent was 0·0427, was W Sin $\theta =$ 2,700 pounds; the total resistance was therefore 4,602 pounds.

Including the weight of the traction engine itself, these figures become 2,251 and 3·002 pounds, giving a total of 5,253 pounds direct resistance, and a coëfficient of adherence of $5{,}253 \div 18{,}348 = 0{\cdot}28$, which slightly exceeds that found on earlier trials of smooth wheels.

Experiments made by Capt. Robt. Merry, at the Jackson Iron Mine, Negaunee, Mich., and the observations and experiments of the writer, indicate the maximum direct tractive force of a good horse to be about 250 pounds. This corroborates the estimate already made, making *the tractive power of this engine equal to that of twenty horses.*

Deducing from the above the weight which could be drawn, on an equally excellent but level road, by this locomotive, the coëfficient of traction being the same, we find it equal to $\frac{5{,}253}{0{\cdot}03} = 175{,}100$ pounds, or very nearly eighty gross tons, and excluding the weight of the locomotive (163,452), seventy-five tons. With the machine, as with the animal, it would not be expected that, in regular work, on ordinary roads, more than one-half of the maximum power would be exacted,* although, with such a reserve, the machine possesses a decided advantage over the animal.

Working Time.—The working time of a horse is usually considered to be eight hours per day for dray horses, and less for carriage horses. The dray horse which is kept in harness eight hours per day, is usually standing unworked a considerable proportion of this time while his load is handled, and also during one-half, usually, of the remaining time, his vehicle is drawn unloaded. The horses of the Third Avenue street railroad, in New York City, are worked less than six hours per day, and are given one day in seven as a day of

* *Vide*, Steam Engines and Prime Movers: Rankine, chap. 3, p. 85.

rest. This is about equal to the working time of horses and cattle crossing our Western plains with moderate loads.

The steam engine requires no such careful limitation of working time. It can work twenty-four hours uninterruptedly as readily as a single hour. Ten hours a day would be, in most cases, made the daily working time of a road locomotive, the period being determined by the proper length of the working day of the driver, rather than by the capabilities of the machine.

The working time of the traction engine may therefore be stated to be, ordinarily, twenty per centum greater than that of the dray horse, and to be capable of indefinite extension when required.

The loss of working time by the horse through illness, at the farriery, &c., and that lost by the locomotive in the repair shop, are proper subjects for comparison, but it is difficult to determine them in the absence of reliable data. We may estimate these losses as equally affecting the two motors, with a probability that the correction of any error in such estimate may make a change favorable to the locomotive.

First Cost.—Comparing the first cost and running expenses of steam and of horse power, we may work from tolerably well established data. The list price of the Aveling & Porter road locomotive, experimented with at South Orange, is, delivered in New York, about $4,000.

The average cost of horses purchased by the Third Avenue Railroad in New York city, is now $157.50, and it would require more than twenty such horses to pull the load of the traction engine, while an addition of twenty-five per cent. must be made for the greater length of the working day of the locomotive. Twenty-five such horses would have a first cost of $3,937.50, to which must be added the large item of cost of harness.

The first cost of steam and of horse power is, therefore, nearly equal, the difference being in favor of steam, leaving, also, on the side of the engine, the immense advantage arising from its ability to work longer hours when required, and indefinitely. The interests on these first costs also nearly balance each other.

Running Expenses.—The running expenses of the locomotive consist of cost of attendance, of fuel, oil and repairs and of depreciation in value with use; those of horse power are attendance, food, stabling, sickness and depreciation with age.

The cost of attendance upon the one engine and the twenty-five horses may be taken at $939 and $3,130, respectively, assuming each

driver of the latter to be able to manage a six-horse team. The engine driver receives three dollars per day and the other men two dollars and a half, and there are are 313 working days in the year.

The cost of fuel, oil, and incidentals, excluding repairs of the engine and its depreciation, may be averaged at $900 per year, in the vicinity of New York. This is somewhat higher than the cost of similar items on railroad locomotives in New York State.*

The cost of repairs and depreciation has been thus far so small at South Orange that it could not be estimated, but for the life of the engine, it will be likely to average something less than fifteen per cent. of the first cost, or, in this case, $600 per annum. This we arrive at by an examination of railroad locomotive expenses,† as officially reported.

The total annual expense, therefore, of the traction engine referred to may be reckoned at $2,439 as a maximum figure, including cost of attendance. A similar estimate will give, for the annual expense of keeping one horse, very exactly $300, excluding attendance. In the year 1870, 10,315 horses in the State of New York cost for stabling, feeding, repairs to harness and shoes, &c., according to the official statements, $3,182,838.24, or $308.56 each animal. From this is to be deducted about eight dollars per head for receipts from sales of horses, leaving for annual expenses, say, $300 per horse. The expense account, excluding attendance, would be, for twenty-five horses, $7,500, as against $1,500 for a similar amount of steam power, *and, including attendance*, $10,500, as against $2,439.

Referring once more to the expense account of the Third Avenue Railroad, we find it working more economically than the average as given above. This company employs an immense number of horses, buys its supplies in large quantities, taking advantage of the market, and is able to do much better than could any individual or smaller capitalists. The following data were kindly furnished by Mr. Chas. S. Arthur:

Average first cost of horses, per head, . .	$157.50.
Average price obtained when sold, (3½ years later,	65.00.
Cost of stabling, general expenses and incidentals,	180.00.
Total annual expenses, including depreciation,	206.43.
Add to the above the cost of harness, (not stated), say, ...	3.00.

* State Engineer's Reports.

† This is about the figure on good railroads in the United States; on British roads the range is from 10 to 25 per cent. averaging very exactly 15 per cent.

The total annual cost of horse power, for comparison, 25 × $209.43 = $5,235.75, to which we add $3,130 for drivers, and we make a total cost per year of $8,365.75, to be compared with $2,439, the total annual expense of the road locomotive capable of doing an equal amount of work.

The expense account when doing heavy work on the common road, under the described conditions, by steam power, is therefore less than 25 *per centum of the average cost of horse power*, as deduced from the total expense of such power in New York State, while *if we take for comparison the lowest estimate that we can find data for in our whole country, we still find the cost of steam power to be but* 29 *per centum of the expense of horses.*

We may state the fact in another way: *a steam traction engine, capable of doing the work of* 25 *horses, may be purchased and worked at as little expense as a team of six or eight horses.*

Prospective.—Thus, thirty years after the defeat of the intelligent, courageous and persistent Hancock and his co-workers in the scheme of applying the steam engine usefully on the common road, we find strong indications that, in a new form, the problem has been again attacked and at least partially solved. It was formerly supposed that success in the transportation of passengers by steam on post routes would lead to the application of that motor to the movement of heavy loads and to agricultural purposes generally. When, after so long a trial, the experiment finally seemed to have failed of success, it was believed that steam could not be applied to heavier work on common roads. As we have now seen, however, it appears probable that the inventors of that day attacked the problem at the wrong point, and that, on the common road, the transportation of heavy loads by steam being accomplished with economical success, under ordinarily favorable circumstances, it may prove introductory to the use of steam in carrying passengers and light freight at higher velocities.

Having examined in detail the capabilities of the road locomotive, and determined the value of steam traction on macadamized roads, and having obtained the measure of its economic superiority over horse-power, there remains to be considered the conditions which favor or retard its introduction, and to determine where it may be adopted without apprehension of failure.

One of the most important of the pre-requisites to ultimate success in the substitution of steam for animal power on the highway is that our roads shall be well made.

As the greatest care and judgment are exercised, and an immense outlay of capital is considered justifiable, in securing easy grades and a smooth track on our railroad routes, we may readily believe that similar precaution and outlay will be found advisable in adapting the common road to the road locomotive.

It is undeniably the fact that, even when relying upon horse-power, far less attention has been paid to the improvement of our roads than true economy would dictate. With steam-power, the gain by careful grading and excellence of construction of the road-bed become still more important. The animal mechanism is less affected in its power of drawing heavy loads than is the machine. With the horse, a bad road impedes transportation principally by resisting the movement of the load rather than of the animal, while with the traction engine the motor is as seriously retarded as the train which follows it, and frequently much more, on soft ground.

Steam, therefore, cannot be expected to attain its full measure of success on rough and ill-made roads; but where highways are as intelligently engineered and as thoroughly well-built as those on which the trials at South Orange were made, or where nature has relieved the engineer and the road-builder of the expensive work of grading, as throughout a very large extent of the western and southern portion of our country, we may expect to see the road locomotive rapidly introduced.

The earliest and most perfect success of the traction engine, and its probable successor, the steam-carriage, may be expected to occur in those districts. Its great economical advantage over animal power, as exhibited above, its freedom from liability to become disabled by epizoötic diseases, its reliability under all circumstances, and the many other advantages which are possessed by the machine, are already securing its rapid introduction, despite the difficulties arising from popular prejudice and unfamiliarity, from hostile municipal laws and other existing obstacles.

We are learning that this motor, when it can be used at all, is comparatively inexpensive; that our roads are improved by it, and that the ancient idea of its conflicting with the interests of owners and workers of horses is only a superstition.

We have found, by our experience with steam fire-engines, with the elevated railroad on Greenwich street, New York, and with railroads throughout the country, that the frightening of horses is but a temporary and a comparatively insignificant inconvenience. It would

seem to the engineer that the natural obstacles generally supposed to stand in the way have, after all, no real existence.

The principal inconvenience that may be anticipated will probably arise from the carelessness or avarice of proprietors which may sometimes cause them to appoint ignorant and inefficient engine-drivers, giving them charge of what are always excellent servants, but terrible masters. Nevertheless, as the transportation of passengers on railroads is found to be attended with less liability to loss of life or injury of person than their carriage by stage-coach, it will be found, very probably, that the general use of steam in transporting freight on common roads may be attended with less risk to life or property than to-day attends the use of horse-power.

This great economical revolution has now made a fair start, and is progressing with most encouraging rapidity. We may anticipate its complete success at no distant period. Meantime every member of the engineering profession may aid its progress by exerting a personal influence in favor of the improvement of our roads and the further improvement of the road locomotive, which has, as we have shown, at last assumed a practical shape, and has exhibited wonderful power. It is now at work in every portion of the civilized world, and the one establishment which constructed the engines above described is now furnishing employment to 1000 working men, supporting a total population, probably, of 5000 people.

Such a commencement having been made in a country like Great Britain, it is difficult to conceive how great may not be the future of this branch of industry when the valley of the Mississippi and our Western plains, the natural habitat of this motor, shall have become finally a principal seat of its manufacture as well as of its employment.

Stevens Institute of Technology, Hoboken, N. J., Oct., 1872.

A patent has recently been granted to H. J. Newton, of New York, for a plan of copper coating iron pipe—the design of the same being to secure a pipe or tube which should be capable of withstanding, for the greatest length of time, the very rapid oxidation which affects the tubular super-heaters for super-heating steam. After numerous experiments with steam super-heaters, the inventor affirms that he has found iron pipes coated with copper to serve the purpose better than any others, and he has secured a patent for the same as a new article of manufacture.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

A regular meeting of this Society was held at its rooms, in New York, on Wednesday evening, November 20th, 1872.

Mr. F. Collingwood read a paper on "Alcohol as an Illuminator in a Condensed Atmosphere," giving account of a comparative experiment, made in the west caisson of the New York bridge, with alcohol and candles, to test their illuminating power under a pressure of 31 lbs., and at a temperature of 80° F.

The lamp had a loose cotton wick, $\frac{1}{4}''$ in diameter; the base of the flame was 2" above the surface of the alcohol. The candle, of stearine, was $1\frac{1}{4}''$ in diameter.

There was consumed per hour, under pressure, 6 cubic inches of alcohol and $\frac{3}{8}$ ounce of stearine, and in the open air 2 cubic inches of alcohol and $\frac{1}{4}$ ounce of stearine.

In the condensed atmosphere the lamp burned with a clear, bright flame, not blue, without smoke, and gave three-fourths as much light as the candle, which smoked greatly.

Taking into account the waste of stearine by flaring and short pieces not burnt, with alcohol at $2 per gallon and candles at 28 cts. per pound, for an equal amount of light that from alcohol costs about twice as much as that from stearine.

It is suggested that a mixture might be made of alcohol and some carbonizing fluid to burn without smoking in a condensed atmosphere, the proportions to be varied to correspond with the change of pressure.

A paper, by Mr. T. Guilford Smith, on "Coal-Cutting Machinery in England under the Present Prices of Coal," was read, which presented the observations of the writer during the late great rise in prices of coal there.

The efforts made in England to cut coal by machinery had not met with much encouragement until a comparatively recent date, when the demand for coal increasing beyond precedent gave the miners a chance to strike for higher wages.

For some time there has been an increasing and alarming difficulty in obtaining a supply of coal at the great trade centres, caused by disputes about working hours, the colliers' strikes, the demand in new iron districts and in foreign countries.

In July last, London prices of coal were from 24 to 32 shillings per ton. Commenting upon this, the "London Evening Standard"

said: "A suggestion has been made, of which we heartily approve, that the importation to foreign ports might be to a certain extent checked by a reasonable export duty on the material which has been called the third necessity of life,—the order running—bread, meat, coal. We may rely upon it that whatever impost we lay, the Russians will still be our customers; but, in addition to them and the Germans, the French, the Spaniards, the Austrians, the Italians, the Egyptians, and even the Americans come to our markets. The French and the Italian governments coal their steam navies from our mines, so do most of the great trading companies of the Continent and the principal packet lines. It is we who set going the locomotives of the Indian, of the Swedish, of the Danube and Black Sea, of the North Russian and of the Egyptian railways."

To determine the merits of the various coal-cutting machines naturally resorted to in this emergency as a saving of hand labor, a competitive trial has been proposed, to take place at an early day.

Probably no machine will in all cases be the best, and doubtless many changes will be requisite to adapt an English machine for use in American mines.

The cost of coal-cutting in England varies from one-half to one-third the total cost of mining.

Several machines were described at length. One, costing £160, driven in pairs by air compressors costing £500, is said to do the work of 40 men in a 2½ or 3 foot seam: it is 6 feet long and 2½ feet wide, and carries at one end a horizontal arm, around which passes an endless chain, provided with strong steel cutters; these cut at the rate of 45 feet per hour.

Another machine, operated by hydraulic pressure, will, by means of a series of reciprocating cutters, arranged upon a horizontal arm, cut 15 yards per hour 4 feet into or under the coal, at any height or angle. It is claimed that with this machine a seam will yield 1000 more tons of coal per acre than when worked in the usual manner.

A third machine, costing £150 and also driven by compressed air, has cutters arranged like saw teeth around a horizontal wheel 3½ feet in diameter, which cuts into the seam 3 feet in depth. Its regular night's work was a groove 120 yards long, 3 inches wide, and 34 inches deep—the proportion of slack to coal being but one to ten.

Other machines, similar in character, were mentioned; also a rock drill, invented by Gen. Haupt, of Pennsylvania, which, after 22 modifications, is now capable of drilling a 2-inch hole in granite 6½ inches per minute.

Should the prices of coal quoted continue for any time, our American fields may have a chance to ship their products into new channels—Nova Scotia having already taken the lead. In October, orders transferred from Liverpool, England, were received in Georgetown, D. C., for large quantities of Cumberland coal, to be shipped to Bombay, Aden, Egypt, Rio Janeiro, and various foreign ports.

Mr. J. Dutton Steele remarked, through the Secretary:—Coal cutting machinery has not thus far been introduced into this country. The operation of cutting coal is chiefly confined to cutting a deep groove or channel in or under the veins so that the miners may pry down the coal that is above it. Generally but one such groove in a vein is required; the cost of cutting per ton of coal will therefore be inversely as the thickness of the veins. The English veins referred to are 2 ft. 10 inches and 2 ft. 4 inches thick. Workable American bituminous veins are from 4 to 8 feet thick, and our anthracite veins from twenty to even fifty feet, which will account, to some extent, for our indifference relative to coal-cutting machines.

There is another reason; powder is freely used by our miners. It is less work to blast out the bottom of the veins than to cut under them, but more wasteful; if powder represents the minimum of labor, cutting under represents the minimum of waste. Nor is waste the only objection to the use of powder; it vitiates the air and occasionally sets fire to the mines.

With cutting machinery, compressed air as a motor will be introduced into the mines, whereby the ventilation will be improved, and the liability to fire reduced. In the anthracite regions, pumping and hoisting engines, with their steam boilers, are put under ground, and shafts cut out hundreds of feet above them for the escape of smoke and steam. Inextinguishable fires in the mines are the direct result of this practice. Steam should be made upon the surface, and there used to compress air to drive the engines below.

I think machines working by impact are preferable to those having rotary cutters. One weighing six hundred pounds, and supplied with a circular inch of air at fifty pounds pressure per square inch, will strike three hundred blows per minute, each with a force of three hundred pounds; and with suitable cutters it should cut under rapidly. By changing the cutters, the machine could drill ranges of holes, which would aid in breaking down the coal. Thereby the waste, liability to fire and the cost of mining would be largely reduced, and the mining interests be more independent of labor.

Mr. Miles Coryell remarked:—Without doubt, coal-cutting machinery, when further developed and perfected, will be useful in mining bituminous coal. It, however, does not seem applicable to the hard anthracite veins of this country.

It is hoped that the use of steam or compressed air, wherever it can take the place of manual labor, will aid in subduing the lawless spirit among the miners, who now work and control our mines.

Mine owners generally are not sufficiently interested in improvements, and do not appreciate the need of a cheaper, safer and less wasteful system, which, with wise encouragement and moderate pecuniary aid, would surely be developed.

In anthracite mines, the seams are irregular and the coal of variable hardness, sometimes interspersed with sulphurets, which resist almost any cutting tool. The diamond drill has been profitably used for drilling long holes between "breasts." With it openings can be made through which noxious gases will escape; it is also of service in determining the position and depth of veins.

More attention should be paid to improving the means of transportation in the mines. A locomotive, with large steam capacity, might be economically employed to draw the cars by day, and to drill holes for mining by night.

The Secretary exhibited models and drawings of machines for boring and drilling rock, and specimens of work done, explained the methods, and stated the cost of operating each.

Prof. De Volson Wood generally reviewed the history of rock drilling by power. He also noticed the difficulties surmounted and yet to be overcome, and the results already secured.

A discussion followed, participated in by most of the members present. The subject of coal-cutting and rock-drilling by power will be taken up again at a future meeting. Members and others are asked to communicate, meanwhile, to the Secretary, for presentation then to the Society, whatever professional experience they may have in the matter.

Carbon Prints on Plaster and Clay.—It is feasible, according to Richard Jacobsen, to secure carbon prints upon wares of this kind. It is stated to possess excellent features, which will secure for it extended application in the future. For burning in such prints, the carbon paper should be coated with gelatin and some fusible pigment instead of gelatin and India ink.

THE ELDRIDGE BOILER CIRCULATION.

No fact is more clearly established than that circulation of water in a vessel in which it is heated is vitally essential to the process of heating. Metals conduct heat from one portion to another through the contact of the particles, but water can only take up the heat by the particle which is directly in contact with the heating surface, which, being thus made lighter, rises and so conveys the heat through the mass, giving place for a fresh particle, which is in its turn heated and moved away.

This condition of things has been recognized ever since the steam-boiler became part of a working machine, as a consequence of the invention and improvement of the engine—and the desideratum with inventors has constantly been to produce that circulation; the importance of which has been fully and universally recognized among intelligent engineers from the earliest period. The estimation in which it is held at present is exemplified in the report of Robert B. Longridge, Chief Engineer of the Manchester (England) Boiler Insurance Company, upon the Relative Economy and Durability of Stationary Boilers, presented in September, 1859, which is quoted and approved in the report of the Committee of the Franklin Institute (of Pennsylvania) upon the Mode of Determining the Horse-Power of Steam-Boilers, presented in June, 1872. (See "Journal of the Franklin Institute," August, 1872, p. 91).

Heretofore the efforts towards the production of this circulation have been almost entirely confined to one class of expedients—that of pipes—necessarily of small dimensions—in which the water, being heated, rises, drawing fresh water after it, and so, gradually, the whole body of the water in the boiler is passed over the heating surface of the circulating pipes, having, however, no proper circulation except within them; such apparatus being always liable to derangement from the loosening of the joints by the different heats and consequent different expansions of the body of the boiler and the different pipes.

This pipe system will be recognized as the basis of the hundred different varieties of "circulating" boilers, and, slow and imperfect as it is, produces results far superior to those attained where there is no circulation at all.

If, however, the whole body of the water in the boiler shall be put into an active and positive circulation over the whole fire surface, con-

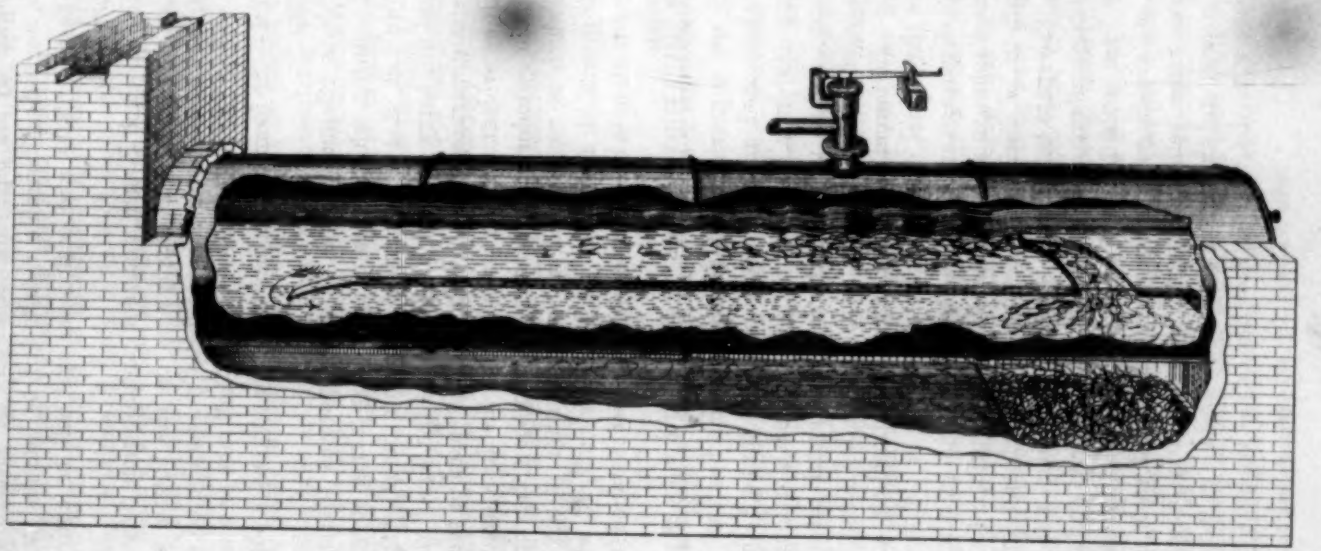
stantly passing from the coolest to the hottest part, all the advantages gained by the pipe circulation will be secured with manifold increase, and other desirable results will be attained, while the evils of over-heated plates and scaled surfaces will be entirely and certainly obviated.

A boiler in which is such a current cannot prime; the swift return current on the surface to supply that on the bottom will force the water to lie flat, no matter how rapid the production of steam or how foul the water. A swift current, as in a mill-race or a mountain torrent, is flat—the foam only comes when the current is obstructed and entangled.

All this is effectually done by the apparatus illustrated in the annexed drawing, which operates simply by taking advantage of the well-known fact, that a gas rising through a funnel-shaped opening in a liquid will carry up with it a current of the liquid whose rapidity is in direct proportion to the supply, and the speed of the gas.

As will be evident from an inspection of the drawing, which represents a plain cylinder boiler broken away to show the circulating apparatus which is represented in section within it, the most of the steam is generated under the diaphragm or shelf, A, which extends from a point close to the head to within a short distance from the rear of the boiler.

This diaphragm is arched from side to side, is depressed near the rear end, and is provided with an apron at its head, so that all the steam so generated under it must pass out through the funnel, B (which is placed over the point of greatest heat), and cannot otherwise escape; and in its passage through the funnel, the steam sweeps with it a rapid current of water, which is impelled toward the rear of the boiler—the funnel being inclined in that direction, and this current from the funnel carries with it the whole of the water which is above the diaphragm toward the rear of the boiler, where it passes under the diaphragm and over the whole fire surface to the hottest part, again to be discharged through the funnel, and to repeat the circuit. The space between the head of the boiler and the head of the diaphragm allows a passage to the rapid current so formed (which is greater than could find vent through the funnel), increasing the circulation and avoiding any space whatever of dead water in the boiler. Thus, fresh water being constantly and regularly presented to the heating surface, and the steam swept away as fast as formed, without interference with the current, it is clear that the heat will be taken



The Eldridge Boiler Circulation.

Photo-lith: by A. DICKES.

from the iron as fast as received, and at the same time the greatest amount of evaporation produced from the fuel consumed, and the iron effectually protected from overheating and from scale.

It is too evident to need an illustration that the same apparatus, with slight modifications of form, is as well applicable to flue and to multitubular boilers, with equal advantage as to prevention of priming and scale, and producing equal increase of evaporative power, and avoidance of destruction by overheating upon the crown sheet and shell.

By guides, easily introduced, the current may be caused to sweep those parts of a tubular boiler in which mud accumulates injuriously, and thus the whole kept clean and in effective working order.

For this apparatus—simple, cheap, effective, and readily applicable to any boiler now in use, without disturbing or deranging it—letters-patent have been granted to me, and I present it to the consideration of all men interested in steam-power, in the economy of fuel, and in the vitality of boilers.

For further information, address G. Morgan Eldridge, 708 Walnut street, Philadelphia, Pa.

WHITWELL'S FIRE-BRICK STOVE FOR SUPERHEATING BLAST IN IRON SMELTING.

During the last forty years Neilson, of Glasgow, proposed to heat the air blown into the blast furnace. The success of his novel idea revolutionized the iron trade. Hot blast was accepted as a necessity, and subsequent improvers have confined their attention to such modified forms of apparatus as would give greater efficiency in actual working.

Pipe stoves were once universal, as were stage-coaches before the introduction of railroads, the chief difference being that in the one case the inconvenience and delay of stage-travelling were confined to outlying districts and the memory of middle-aged men, whilst the inconveniences and delays of pipe-stoves have caused anxiety and loss to most of the present furnace owners all over the world. Siemens cut the Gordian knot of economical heats, and Cowper applied to hot blast the regenerative principle that Siemens had patented, and obtained heats and economy of fuel that previously had been quite unknown, coupled with enlarged production. Cowper's stove has not had the

measure of success that its principle undoubtedly entitles it to, as engineering imperfections and mechanical faultiness in construction have been much against it. Whitwell's stove is an improvement on the Siemens-Cowper stove, and is remarkable for its power, its longevity, its simplicity of construction, and, above all, its never getting out of order, or—rather to tabulate the distinguishing advantages of these stoves—

1st. That they will stand a temperature of 2000 degrees without damage.

2d. There is *no* wear and tear of cast-iron pipes or material.

3d. These stoves are sooner cleaned than any others, the time required between laying off and starting again being 6 hours; they are not cooled down, but are cleaned from the outside while red-hot; this occurs about every two months.

4th. The principle on which the stoves are constructed insures the greatest economy of gas or fuel, whilst the heat that is obtained in the blast is nearly the whole of that given off by such gas or fuel.

5th. The cost of the stoves is not proportionately more per furnace than that of ordinary cast-iron plant, equal to modern requirements.

6th. These fire-brick stoves effect a saving of several cwts. of fuel, per ton of iron made, and largely stimulate the production.

7th. The stoves being rivetted and caulked air-tight, there is no loss by bad joints, and hence a large amount of wear and tear is saved to the blowing-engines.

8th. The areas throughout are so regulated that there is *no loss* of pressure by friction, but a pressure of 4 lbs. in the engine-house gives *an equal pressure at the tuyere* where the plans of the patentee are properly carried out.

9th. The immense reservoir of caloric stored up in these stoves (each red-hot wall acting as a fly-wheel, so to speak, and giving out its power when most required) produces the best effect on the working of a furnace, preventing its running off into inferior qualities of iron.

10th. These stoves form *a perfect regulator* to the blast, acting in this respect as the air-vessel in a force-pump, and dispensing altogether with the large air-regulators that are found necessary in many works, the blast being perfectly steady at the tuyere.

These stoves have been used for seven years by the firm of William Whitwell & Co., South Stockton-on-Tees, England. Two years since, the Consett Iron Co., Durham, erected their fourth set of four, and

Photo-lith'd by A. DICKES.
WHITWELL'S HOT BLAST FIRE BRICK STOVES
Phila.

Fig. 1 .. Vertical section

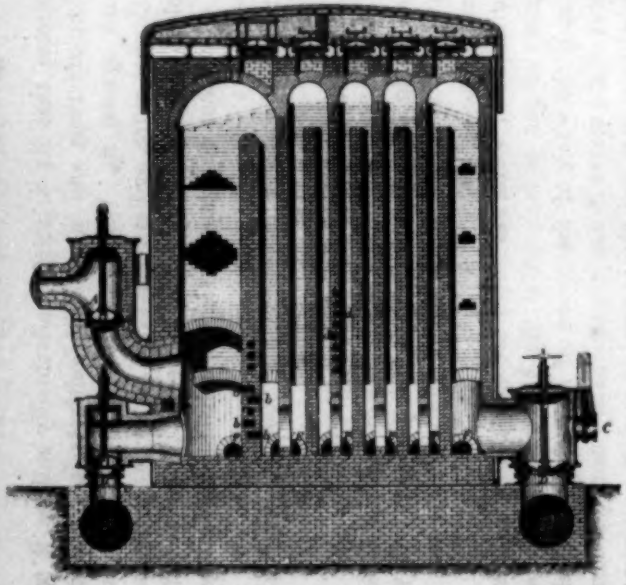
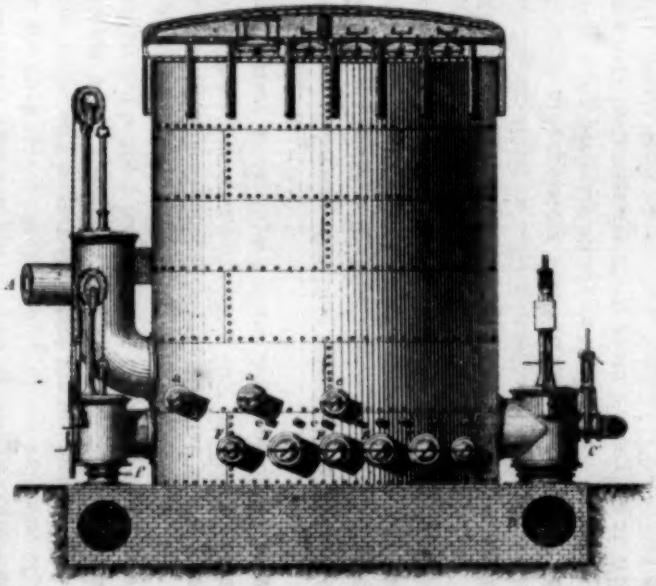


Fig. 2 .. Elevation.



WHITWELL'S HOT BLAST FIRE BRICK STOVES

Photo-lith: by A. DICKES. Phila.

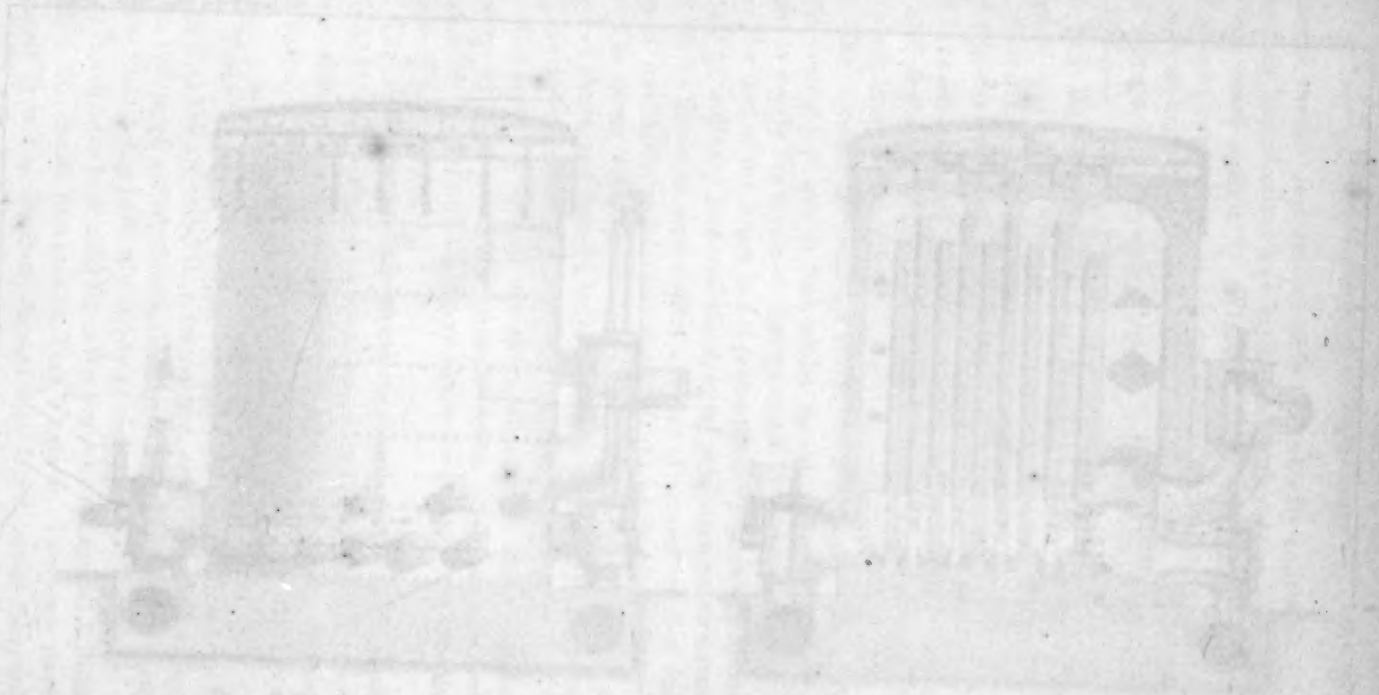


Fig. 3 — Horizontal section.

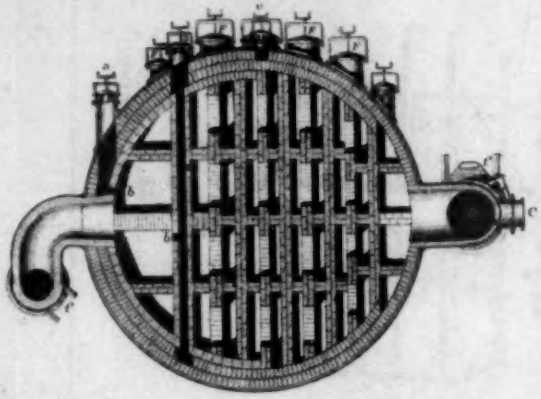
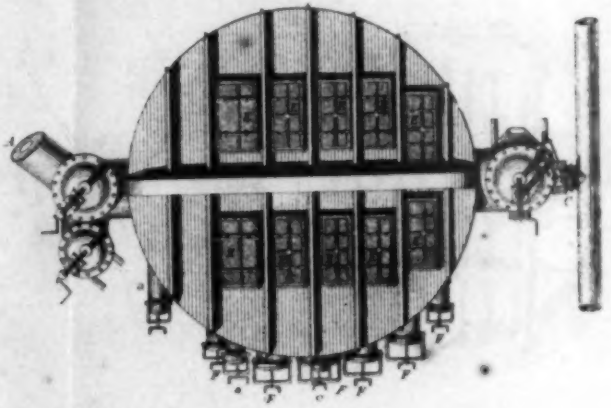
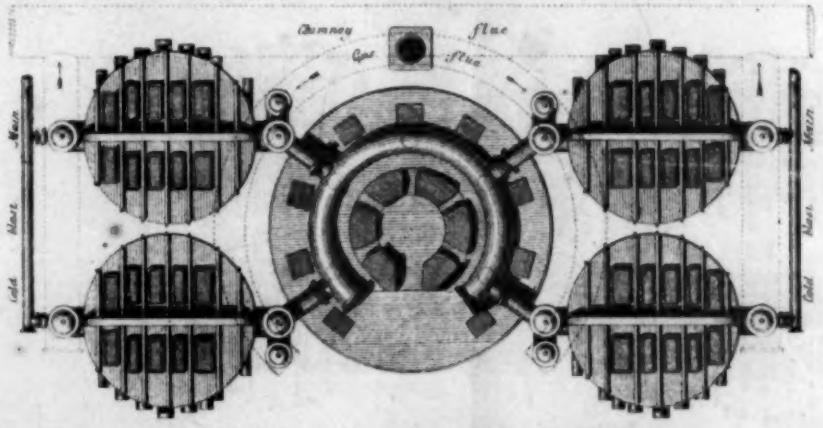


Fig. 4. — Plan.



PLAN SHOWING ARRANGEMENT OF WHITWELL'S STOVES AT THE CONSETT WORKS



WHITWELL'S HOT BLAST FIRE BRICK STOVES

Photo-lith: by A. DICKES.

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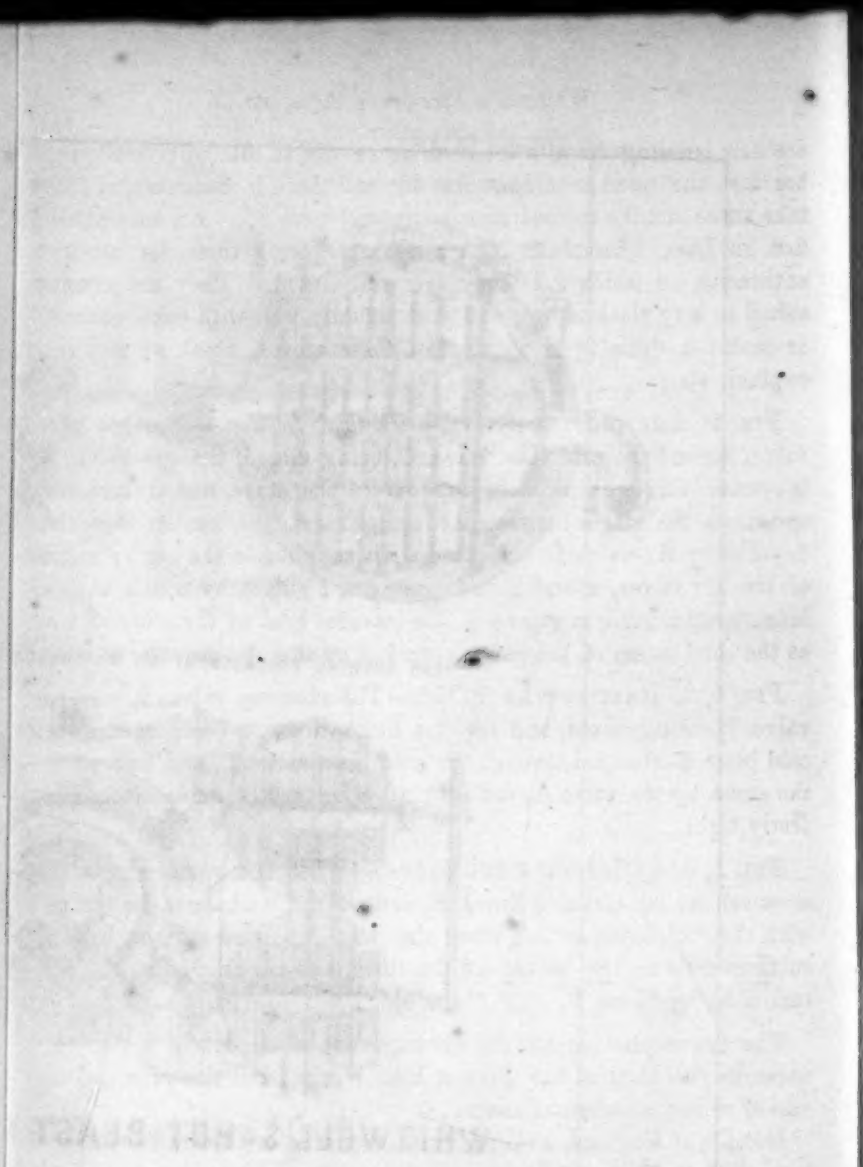

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are now building the fifth set, making twenty in all. Up to September last the number in blast was 44, and those in construction (they take three months to construct and erect) were 86. An enterprising firm on Lake Champlain, N. Y., are introducing them, for use with anthracite, to which fuel they are well suited. They are equally suited to any class of ore, and work equally well with coke, charcoal or coal. A drawing is annexed of these stoves, which we may thus explain, viz.:

FIG. 1. HEATING THE STOVE.—*Vertical Section.*—The hot blast valve, A, and the cold blast valve, C, being closed, the gas valve, B, is opened, through which the gas enters the stove, and traverses up and down the spaces between the upright walls, and enters the chimney flue by the valve D. Heated air is supplied to the gas by means of the air valves, *a* and *c*, and passages, *b* and *d*, by which a most intense combustion is gained. The internal heat of the stove as well as the combustion of the gas is observed by the eye-pieces, *e e*.

FIG. 1, 2. HEATING THE BLAST.—The chimney valve, D, and gas valve, B, being closed, and the hot blast valve, A, being opened, the cold blast is admitted through the cold blast valve, C, and issues from the stove by the valve A, *red-hot;* all other valves being closed perfectly tight.

FIG. 1, 3, 4. CLEANING THE STOVE.—When it is required to clean a stove, the top cleaning-doors, E, are opened and the walls scraped with the "cleaning-tools," when the dust deposited on the heating surfaces falls to the bottom of the stove, and is removed by the bottom cleaning-doors, F.

The lower plan shows the arrangement of the stoves to four furnaces *in full blast* at the Consett Iron Works; but this plan may be varied to suit all circumstances.

Outside of England, France, Prussia, Alsace and Lorraine, Luxembourg, Westphalia and Spain have adopted them with perfect satisfaction. Patents have been granted for this invention in Great Britain, France, Belgium, the United States, Luxembourg, Russia, Austria, Spain, Portugal, Sweden, Norway, Italy, the East Indies and New Zealand.

Chemistry, Physics, Technology, etc.

PREMATURE DECAY OF TIMBER.

(Suggested by an Examination of the Wreck of the late Steam Frigate Chattanooga.)

By Hector Orr, Member of the Institute.

Read before the Institute, Nov. 22, 1872.

We are generally aware of the building and equipment of the frigate Chattanooga at this port about the close of the late war. We also know that this vessel was injured by the ice and partially sank off League Island last winter. During the summer just passed she was sold as a wreck and bought by Mr. Alexander Purves, long known in the iron trade of this city, and who is an active member of the Institute and also of its Meteorological Section. At a meeting of this Section I inquired of Mr. P. concerning this wreck, and to his politeness I am indebted for the opportunity of examining the same and presenting these few thoughts thereon to the Institute.

I found this vessel (or at least her hull) lying on the flats above Gloucester City on the New Jersey shore. Her length over all was 350 feet, with a keel alone of 300 ft. Her outfit embraced a three-blade propellor 18 feet in diameter, of tough compound metal, and a powerful steam engine of Merrick's best workmanship.

All the machinery had been removed and the work of demolition had begun both fore and aft from the bulwarks downward; but the great mass of her bulk was there. The amount of "dead wood" presented at the bow and stern was enormous. The stern, as the seat of the propeller, required an extra mass, and the bow seemed intended to act the part of a naval "Ram." The "ribs" or timbers were but a few inches apart and had chock-braces at every few feet, and amidships, diagonal wrought iron straps were placed in abundance across the timbers.

All the just constituents of a noble ship seemed to be there, and each in its right place; but in all this structure there was scarcely a sound piece of wood six feet long! White pine, yellow pine or oak—ribs, planking, lining or deck—all were smitten as with a common plague, presenting a mass of rottenness which crumbled at your tread, nay, even at your touch!

Less than eight years ago the keel of this ship was laid. She

scarcely left the waters of the Delaware, never threw a broadside or saw an enemy. The Rebellion waned as she grew into shape, and expired almost at the first movement of her engine. Thus far she had a happy history—that of her remaining life is far different.

Mr. Purves has dealt with other wrecks of various dates of life and service, and in his company I met experienced seamen and ship carpenters, and they all unite in saying that they never saw the like of this! Numerous specimens of this wreck will be found on our table, marked as to position and kind of wood, taken from the kelson upwards. Near the forward bends the timbers were *doubled*. I noted one or more instances in which a pine log and an oak log were thus coupled, and the decay had evidently began at the inner surfaces, which were in direct contact with each other; but even where both logs were of the same wood the same inward decay appeared. Whether in the undisturbed mass, or where pierced with iron or copper fastenings, or even with the humble tree-nail, the fibre was completely broken up.

My friend Dr. Reynell Coates has reminded me that the fleet of Commodore Perry, which was built in haste from timber cut on the lake shore for service in the War of 1812, suffered from early rot, so that the vessels were pronounced unseaworthy soon after the peace of 1815.

Also, Mr. Purves assures me that he has known a strange tendency to decay in some vessels, indicating a sort of triennial crisis in their early life, which, if passed without injury to the wood, predicted some twenty-five years of wear. It is somewhat analogous to the test of the third summer in children. I do not insist on the analogy, but we may recollect that out of such unpretentious facts as we are here recording, Newton and Franklin started their wonderful discoveries.

I have learned from Mr. Durfee (Supt. of the Midvale Steel Works) that he has witnessed a few marked instances of decay in large pieces of timber, such as pillars, girders and even rafters, that were *cased* in light boards to improve the appearance of the room; the inner mass being found dangerously rotten. And here I will take the liberty to say that I have for full forty years watched the not very graceful deflection of our girders in the ceiling above us, and I think that it may be worth while to test their internal solidity at some convenient season not far distant. If we let this hint come "home to our business" now, it may prevent its coming "home to our bosoms" unpleasantly eventually.

Mr. Purves has farther noted the decay of wood on shipboard under circumstances which seem to me quite worthy of attention: On por-

tions of the "lining" of vessels covered with zinc or tin, as in provision closets, &c., the decay followed exactly the surface covered by the metal, indicating the action of "dead air" in contrast with that of a free atmosphere on the surrounding parts which remained sound.

The observations of both the gentlemen last quoted point to a state of things very similar existing between the timbers of the Chattanooga, enclosed by planking outside and by the lining or ceiling inside—chambers for dead air were thus formed throughout the entire hull; and the other testimony kindly offered me by others, I hope may tend to give us the clue to avoid in future the sad result which furnishes the title to these remarks.

I have already alluded to the short duration of our war navy on the Lakes. Its vessels were built in haste for a pressing emergency. The same is true of the Chattanooga; but nearly sixty years have passed since Perry's victory, and what years of progress have they been! In them have arisen the ocean steamship, the locomotive, and the railway, the telegraph, and the FRANKLIN INSTITUTE. We have had various processes brought out in this period for the preservation and speedy seasoning of wood. I could not name them all, much less describe them; I will mention one, however, which seemed to me worthy of attention from its simplicity and apparent effectiveness. It is perhaps fifteen years since my friend, Mordecai R. Moore, late member of our City Council, made known to me what he considered a valuable improvement in the seasoning of timber. I am not sure that the invention was patented. It was not invented by Mr. Moore, but he was persuaded of its value. The process consisted in charging the freshly-cut wood with super-heated steam, for a period of twenty-four hours; then by powerful apparatus exhausting all fluid from the fibre, and charging it anew with dry and highly-heated air for another twenty-four hours; and on the third day the wood was ready for use.

Like too many of the group, which seems but a few at best, Mr. Moore is dead; and thus far I have not been able to trace up this invention in present hands. Even if it was patented, its date must be out by this time; but the process certainly ought not to be forgotten. If this marvellous decay which I am relating to you, is due to the haste with which the work had to be done, surely this two days' process would not have delayed it much; and look at the consequences! In the condition in which Mr. Purves took possession of this vessel, she had hardly the strength of a partition of lath. She sank before the ice last winter, because her empty bulk was too much for her

strength even in the placid waters of the Delaware. In her first storm at sea she would have been but a ready-made coffin of unusual shape to all on board.

There is still another consideration which I will present here, as to the hygienic condition of such a structure. Some seventeen years ago, our venerable and excellent citizen, Dr. René La Roche, set himself to write the history of the *Yellow Fever*. It is in two thick volumes 8vo, and I read the "proof" of its pages. It embraces piles of conflicting testimony, but at least one definite conclusion was attained, to this effect—that in all well ascertained centres of production and diffusion of said disease, three conditions were always present, namely, *heat*, *moisture* and *decayed wood*. Now, mark this; I am quoting from a work at least seventeen years old, yet follow me aboard this unfortunate vessel for a few minutes, and see how it applies there. As to moisture, her mere bilge water would furnish this, even without the drippings from tanks and boilers; the heat is insured by her furnaces, which a cruise in the tropics would aggravate, and surely the *rotten wood* was there at once in profusion and perfection. Ponder the fate of this ship's company; danger without and covert, lurking death within—around poor Jack's humble hammock and in his very nostrils.

And to show you that I am not drawing upon fiction, our observant Actuary informed me, a few days ago, that one of our physicians had actually detected a well marked disease on board this very vessel.

Mr. President, I have no special personal interest in this case of our abandoned frigate, and surely take no pleasure in this recital. But we participated in the fame of the noble ships which for a hundred years have been built here, and we must share in the shame of this one.

I will close with the hope that we may never see such another war as the one we have happily closed, nor such another war-ship as the one I have just examined!

DISCUSSION.

Mr. CLOSE arose to correct a portion of the statement in Mr. Orr's paper as to the Chattanooga never having left the waters of the Delaware river. Mr. C. went on to state that the contract required the ship to have a trial at sea, the wheels to be turned a certain number of times, and consume a certain quantity of coal in a given time, and under the supervision of Mr. Zeller, the chief engineer, the test was accomplished, the ship being at sea three days.

And as to the decay of the wood, Mr. C. went on to state that at the time the ship was building no yellow pine timber of good quality could be obtained, (during the Rebellion), and a substitute had to be made of the Bastard or Norway pine, then growing in Northwestern Pennsylvania, which has little or no traces of the resinous material as found in the yellow pine grown in the Southern States; in fact, an expert will tell within fifty miles of the latitude where a certain piece of yellow pine grew, if shown to him. The decay commenced in the sap of the Norway pine, caused by want of ventilation, which disease was communicated to the oak frame by contact and want of ventilation. Woods that have been preserved under water on the Kensington side of the Delaware river have been laid on the ground at Petty's Island and rotted to spunk or earth in one year, while the same wood laid on the ground on Kensington side showed no signs of decay after remaining several years exposed.

Mr. C., on being questioned as to the time of year of the cutting of the timber having something to do with the decay, he stated that that theory was approved by workers of timber, but he had very little faith in it.

Mr. ORR gave pointed attention to the remarks of Mr. Close, and then rejoined that he certainly had understood from Mr. Purves that the vessel had never gone to sea. He was rather incredulous still as to the actual length of her longest voyage. All the other explanations of Mr. C. confirmed Mr. Orr's specifications. He inquired of Mr. Close if he was acquainted with the "seasoning" process of Mr. Moore, which had been described, and on Mr. C. disclaiming any knowledge of the same, Mr. O. ended his response by saying he was glad to learn that the Chattanooga had gone far enough to get her worthy contractors their pay, which he believed was the only good thing done by said vessel.

Mr. DURFEE said his knowledge bearing on the immediate subject under discussion related mainly to the case of a church of quite recent erection, whose rafters or roof timbers had been enclosed in attractive casings to give finish to the interior, and upon occasion arising for the application of nails to said ceiling, at the single stroke of the hammer the nail penetrated to its head, the inner wood being quite destroyed.

Mr. CLOSE recollected a very similar case in a roof where the enclosed wood was reduced to comparative powder.

The Treasurer of the Institute, Mr. FREDERICK FRALEY, (who had

already reported a series of obituary resolutions on the death of Prof. Frazer, and given an extended extempore address on the lamented Mr. Agnew), rose and apologised for again taking the floor, but urged the importance of the subject as his excuse. After alluding, parenthetically, to the severe loss by fires within the past twelve months, especially in Chicago and Boston, and inviting the attention of the Institute to the devising of additional means for meeting and preventing such calamity—went on to state his experience in ship-building in the unpretentious item of canal boats, in whose structure his Company had been induced to dispense with the inner covering (or ceiling), and by a strong outer planking carefully joined and calked, the inner surface of the ribs was left bare, with a decidedly improved result on the endurance of the wood, proving the valuable effect of free circulation of air and the action of light also in such instances.

The PRESIDENT (Mr. C. Sellers) also offered further testimony condemnatory of the practice of insulating wood from the action of light and free air. In his own house (of comparatively late construction), he accidentally detected a serious defection in his principal floor—the ends of its joists being almost uniformly rotted off even with the wall in which they had been inserted; while in a very old family building (viz., that of his grandfather), the joists were found to be uninjured; but said joists presented their ends to the air, which had free access to their surface.

Mr. ORR rose, by permission, to call attention to the remarkably uniform tendency of the testimony volunteered as to the evil of enclosed timbers, and he was afraid that it leaned too much in one direction. He appealed to Mr. Fraley's recollection of Cope's first line of packet ships, built by good Robert Burton on an average of 50 years ago. Those ships ran regularly for 25 years on said line and then were sold as whalers, and were perhaps still afloat. The present Tuscarora (the second of the name) was still a model of strength and beauty, though once struck by an iceberg full 20 years ago, and again having the misfortune to lay aground near Cape Henlopen through a part of a winter. Yet all these ships were built with *enclosed timbers*, planked and ceiled, on the very plan which we now seemed ready to condemn! He wished the subject to be looked at, not only on both sides but all around. He had met some bluff specimens of *artists* on board the wreck, who vowed their belief that "wood *growed* different now from that cut long ago." He had thought much on this terrible decay of wood, both in ships and bridges and in street pavement, and hoped members would take the consideration of the matter home with them.

Mr. FRALEY fully endorsed Mr. Orr's description of those noble ships of other days, and admitted their strange contradiction of our present experience in this department of mechanics. He wished to call attention to one more fact on the general subject—that at the dates to which Mr. Orr, referred it was the practice of Philadelphia shipbuilders to apply coarse salt between the timbers of the best ships.

The Session having now been extended beyond the usual time, the discussion was arrested for the present by a motion to adjourn.

BITUMINOUS COAL; ITS ORIGIN, VARIETIES AND A FEW OF ITS SPECIAL USES.

The substance of a paper presented at the Dubuque Meeting of the American Association for the Advancement of Science.

BY E. B. ANDREWS, of the Ohio Geological Survey.

Notwithstanding the elaborate attempt of Bischoff and others to prove that coal is an accumulation of vegetable detritus, drifted by rivers and buried beneath accumulating sediments in the ocean, this view is not now accepted by any who have carefully studied the coal seams in the Coal Measures in America. Lesquereux and Dawson have shown, as the results of careful and extended observations, that the vegetation forming seams of coal grew where it is now buried, the only movement being downward, in the general subsidence. By this subsidence, sedimentary materials were brought in over the vegetable mass, filling up the water so as to form, in time, a new subaërial surface, on which new vegetation took root and grew, to form in turn, when buried, another seam of coal. My own independent observations, continued through many years, convince me that in no other way were the seams of coal in our true Coal Measures formed. There is, moreover, every evidence that the vegetation grew upon marshy plains, more or less extensive, skirting the ocean, or, perhaps, often constituting low islands not far from an ancient shore. This appears from the fact that the slates and shales accompanying the coal and in immediate proximity to it, often contain marine or brackish-water forms of late palæozoic life. These slates sometimes constitute partings in the coal seam itself, and extend for miles, maintaining with wonderful exactness their stratigraphical position. These partings imply a temporary overflow of the ancient marsh by the ocean, and an even distribution of sediment, which when compressed constitutes the thin layer of shale or clay. Besides, we find in the very coal

itself, and especially in the cannel portions of seams,—for cannel coal is, so far as my observations go, only a local modification of a regular bituminous coal-seam,—marine forms of ancient life, of which *Lingulæ* and fishes are, perhaps, most common.

We also find in some seams of coal the evidences of tidal or other overflow of the coal-marsh, in beach-worn sticks and various forms of wood which, now changed to bisulphide of iron, are preserved in their original form, and lie in the coal as they were drifted into the old marsh. After the complete subsidence of the whole marsh, we often find the proofs that such trees as *Sigillaria*, *Lepidodendra* and taller ferns were broken down where they grew, by the incoming waters, and buried on the spot by the sediments. I once traced the trunk of a *Sigillaria* in the roof of the Pomeroy, Ohio, seam of coal, for a distance of more than forty feet. Thousands of the trunks of what Lesquereux takes to be *Pecopteris arborescens* are found in the slates over the same coal, lying in horizontal burial as they were bent or broken down by the waters which also brought in their stony winding-sheet. In making almost thousands of geological sections in our Coal Measures, I have found seams of coal always maintaining such relations to what were the ancient water levels, that I am fully convinced that in every case the vegetation grew along the water-line and not far above it.

I have never found the slightest proof of the formation of a seam of coal over hills or high grounds. The parallelism of the seams, of which further mention will be made, forbids it. Doubtless, vegetation of certain kinds grew on the higher grounds, but this vegetation did not constitute seams of coal. It is plain that whatever vegetable matter there might be on a hillside would in the subsidence of the land present to the waves of the encroaching sea an easy prey, and the trees and humbler plants would be torn from their exposed moorings, and be drifted away to rot upon the waters or be buried in the sands of the beach.

Such drifted and buried trees are frequently found. Should there have been some high level plateau, on which vegetation grew, and which in the subsidence was let down below the water so evenly as t prevent the waters from tearing the vegetable materials away, it is still doubtful whether, on such high and dry areas, there would have been any considerable accumulation of vegetable matter, the decay so equalling the growth, that in reality there would have been no materials for a true seam of coal.

While the vegetation forming the coal seams grew upon marshy savannahs skirting the ocean, we find constant proof that the continuity of the marsh was often broken by intervening water, so that the seam of coal is frequently interrupted. In the subsequent subsidence these water spaces were filled up with sands or clays, which are now hardened and compressed into shales and sandstones. But if we have a marsh at one point which continued long enough to allow of the accumulation of vegetable matter sufficient for a considerable seam of coal, the presumption is that on that exact horizon we shall find that there were other areas above the water on which vegetation also grew, and thus along one water-line there be formed a seam of coal, varying in its fortunes of thickness and quality, ranging, with many interruptions, through many counties and perhaps hundreds of miles. A long period of rest from downward movement, such as the growth and accumulation of a thick seam of coal imply, almost necessitates the fact that, during that long period, wherever there were along the water-line areas of low-land, whether insular or continental fringes, on which vegetation might take root and grow, there would be such growth, and consequently a seam of coal. We, in fact, find this to be the case, so that, in tracing a seam of coal, we learn where the water spaces were, and where even the smaller channel-ways extended through the ancient marshes. These water spaces, wider or narrower, we are able to cross, preserving accurately the level, and thus find the coal at other points always in the same geological horizon.

When the subsidence took place, by which the marsh or marshes of one horizontal line were lowered beneath the water, the presumption is that such subsidence would be an even and regular one. We can hardly suppose that, within any limited area, there would be any considerable inequality in the sinking, any irregular plunges downward here and there, so as to tilt at various angles the plane of the coal. The subsidence was of course greater in some districts than in others. In Nova Scotia there are 14,570 feet of productive Coal Measures, with over 80 distinct seams of coal; in Eastern Pennsylvania 3000 feet are reported; while in Southern Ohio the highest coal-seam yet found is about 1500 feet above the Waverly sandstone, on which at places a seam of coal with its under-clay is found to rest, with no intervening conglomerate. It is also entirely possible that, when any *large areas* of any one coal-field are carefully investigated, it will be found that some portion of such large area may have had a some-

what more rapid subsidence than the rest.* But, as a rule, the subsidence was so regular that two seams of coal, each formed on its water-line, are found to present an almost perfect parallelism. For example, in Ohio, the Nelsonville seam of coal is found, in the vertical series, to be 420 feet below the Pomeroy seam. These two seams range through many counties, and everywhere the interval between them is exactly the same. The same is true of all other well-defined and continuous seams. One careful measurement of the interval between two seams is so excellent a guide that, either seam being found, the place of the other can be readily determined. There may be difficulty in ascertainiug the exact interval, because there may be considerable horizontal distance between the exposures of the seams, and calculations must generally be made for the dip, usually an unknown term; but when the measurements are accurate the parallelism is perfect and beautiful. There is a little play of variation sometimes, but it is generally very slight. In limited areas this could hardly be otherwise. Even in cases of earthquake action we generally find the areas of elevation or subsidence to be quite extensive. But there is no proof that in the Coal Period there was any intense earthquake action, nor any convulsive disturbances which would give to the plane of a coal-seam great irregularities in inclination. It must be remembered that the elevation of the Alleghenies and the foldings of the Appalachian region and all the thousand undulations given to our coal-fields were subsequent to the formation of our Coal Measures. The results of the most careful observations in all our coal-fields create a reasonable belief that the subsidence was semi-continental in character, and that the crust of the earth settled down in an even and dignified way.

So far as my own observations go, I have never found an instance where two distinct seams of coal came together, or conversely, where a seam becomes divided and its parts continue to diverge for a long or indefinite distance. It is not uncommon to find in a seam of coal the proof that the coal-marsh had in it local depressions, which were filled with sediment, making a soil on which new vegetation grew, and thus the seam shows two parts, separated by fire-clay, sometimes several feet thick; but in every instance, when traced, I have found the parts to re-unite. The two parts never diverge inde-

* I have myself reported a case of this kind in Ohio, during the earlier portion of the Coal Period, but the supposed proofs of this are undergoing careful revision.

finitely. From these statements we may infer a general law of parallelism. Such law is in harmony with the belief of the most careful observers, that our productive Coal Period was characterized by great quietness, and freedom from violent local disturbances.

Lesquereux, who visited the Dismal Swamp in Southeastern Virginia, reports that the Drummond Lake, which is fifteen feet deep, has beneath it the usual vegetable matter characterizing the bed of the surrounding swamp. Now, if this lake were filled up with earthy sediments and swamp vegetation should grow and accumulate over them, and afterwards the whole vegetable matter of the entire swamp were buried and changed to coal, we should have in the central area a divided seam or two parts of one general seam. If, by some more recent eroding agency, half of the whole area, including half of the area once occupied by the lake, were swept away, we might find the two parts of the seam of coal showing an increasing divergence to the point or line of erosion, and unless checked by deductions from previous observations, we might suppose the two parts to go on diverging indefinitely. There may be exactly similar cases in our coal-measures which mislead because we obtain a view of only a part of what constituted the original area of the seam. In the *Student's Elements of Geology*, as also in the *Elements*, Sir Charles Lyell brings forward an instance of the supposed coming together of seven widely different coal seams in Pennsylvania, and he explains, with the aid of a diagram, the method by which such union might be brought about. The explanation is by the subsidence of a part of a marsh and the silting up of the water over the submerged part, thus forming a new surface continuous with the not submerged. If such submergence is local—and he speaks of a "lagoon" in a swamp—the division of the main coal would be only a local duplication. But the coming together of widely different seams—each formed originally upon its own water level—not only involves unequal subsidence, but, what is more difficult of belief, that there was a limited area where all the seams met, which balances itself at the water's edge, while the adjacent area was sinking and filling up for new marshes, and this repeated, many times over. The following is Lyell's statement of the facts as he obtained them in his visit to the United States in 1841, from the late Prof. Rogers: "Between Pottsville and Lehigh Summit Mine seven (of these) seams of coal, at first widely separate, are, in the course of several miles, brought nearer and nearer together by the gradual thinning out of the intervening coarse-grained strata and their ac-

companying shales, until at length they successively unite and form one mass of coal between forty and fifty feet thick, very pure on the whole, though with a few thin partings of clay." When we come to examine the *Geological Report of Pennsylvania* by the late Prof. H. D. Rogers, we find that these several seams have not been *proved* by any stratigraphical observations to come together; they have not, by the comparisons of carefully measured sections at different points, been found showing a convergence, but we have in place of facts only a theoretical conclusion, adopted for the purpose of explaining the unusual thickness of coal at Summit Hill. I quote all Prof. Rogers says on the subject:

"The only question open to discussion is, whether in an instance like that of the huge mass of the Summit Hill Mines and Panther Creek tunnels, where the bed possesses very unusual thickness, the expansion of its size is caused by the merging into the principal bed of other adjoining coal seams through the thinning away of the dividing strata, or is merely a local enlargement of the one coal bed between the same roof and floor, arising from more active deposition at this spot of the vegetable materials which formed it. If we were in possession of any complete sections of the lower coal measures, such as those of the Nesquehoning and Tamaqua coals, illustrative of the condition of things nearer to the Summit Mine than those localities, we might, from such data possibly determine the running together or not of some of those beds to form this great deposit; but no intermediate points have been developed, and the distance of the two localities named, one 4½ miles and the other 5 miles, is too considerable to permit us to institute any close comparison between the individual beds at either of them and that of the Summit. To explain the unusual thickness of the great bed by the coalescing of several large seams of the Nesquehoning group, we must assume, if we take the "main lower coal" and the two next which overlie it, as those which have here come together, that there has occurred a total exhaustion of about 134 feet of included rock, or if we suppose only this "main lower coal" and the double or Rowland's coal to have united, we have still to conceive of the thinning out of 77 feet of sandstone in a range of only 4½ miles. A like difficulty besets us when we consider the thick plates of sandstone and slate which we must assume as having disappeared between the Little Schuylkill and the Summit if we would derive the great bed from the coming together of any two or more of the principal lower seams of that locality. Nevertheless, so much more uniform

are the coal beds generally than the mechanically derived sandstones —so much more easy is it when we advert to the respective circumstances under which these two classes of deposition originated, to ascribe a rapid variation of thickness to the wildly-strewn strata of sand and pebbles than to the slowly and gently accumulated layers of vegetation of the ancient carboniferous marshes—that I strongly incline to that view which assumes the apparent alteration of thickness to be due to the thinning out of the arenaceous rocks."

From this language it appears that no facts have been obtained by careful stratigraphical measurements to prove the actual coming together of the different seams of coal, but the union is assumed as on the whole the least difficult way of explaining the unusual thickening of the coal at the Summit. This, of course, is only the opinion of Prof. Rogers' and is entitled to all the weight which the opinions of so eminent a geologist should receive. It is readily granted that sands are accumulated along shore lines with great uneveness. This depends upon the strength of currents and the quantity of material. Along a shore there are places of comparatively quiet water, where finer sediments, now compressed into shales, are deposited, and we often find these shales alternating with sandstones. In Ohio on the same horizon I find sometimes 60 feet of sand rock and a few miles away 60 feet of shales. The marginal area below the water must be filled up with something and the uneveness of the resulting bedding of the sand rock or shales is not a matter of consequence, nor is it pertinent to the solution of the problem in hand, viz.: the explanation of the unusual thickening of a coal seam at a given point. The real difficulty is antecedent to the filling in of a submerged area by mechanical sediments, it matters not whether by "sand and pebbles widely-strewn" or by mud gently dropped in more quiet water. How came a part of a marsh with its coal-making vegetation 134 feet below its original level, while the remaining part of the marsh maintained such a wonderful statical equilibrium just at the water level? I do not say that this is impossible, but it is not probable, indeed it is so improbable that it may not be lightly inferred.

If we accept Prof. Rogers' theory of union of seams to form the great Summit seam, for example, the seams found at Nesquehoning, what are we to conclude becomes of the great aggregated seam as we go towards Tamaqua? The great seam has a geographical limit to its greatness. If its parts separate again and in their divergence constitute the Tamaqua coal seams, then we have the interesting fact

that a mere bit of an ancient marsh held itself bravely up above water while all around it the earth kept sinking, interrupted only by those long intervals of repose in which new marshes were formed, upon which grew the vegetation of the successive seams of coal. Such stability in the midst of instability is highly improbable. If, on the other hand, the great Summit seam is not thus divided into diverging parts, but gradually becomes thinner and extends towards Tamaqua, and is represented there by some smaller seam in that direction, then the question very properly arises—why, if a seam of coal may thin out toward Tamaqua may it not also towards Nesquehoning, and thus render unnecessary the assumption that several distinct and widely separated seams have coalesced?

It is much easier for me to believe that in this famous Pennsylvania case, now made historical by Sir Charles Lyell, the conditions of accumulation of a large mass of vegetable matter were more favorable at that part of the marsh now represented by the Summit Hill coal, than at other portions of the marsh. The conditions of growth might have been very different, or there might have been different degrees of waste from decomposition, or even by mechanical removal. Indeed all these causes might have combined to create the difference in the thickness of the coal. In Ohio I find a seam of coal from 4 to 5 feet thick and evidently retaining its original and normal thickness, while 3 miles away the same seam is nearly 13 feet thick. It is as easy for me to believe that a seam might at Nesquehoning be 28 feet thick, and at the Summit Hill be nearly 50 feet thick, as that a seam in Ohio should in a less distance change from 4 to 13 feet.

I am well aware that published sections, taken in a very limited area, sometimes show such a wide variation of intervals between so-called proximate seams of coal that any parallelism seems entirely out of the question. In one case, within the area of a county, where there were five seams of coal in the vertical series, the intervals between each two consecutive seams are given. The published figures show that, in the subsidence, before the second seam from the bottom was formed, the originally horizontal plane of the bottom seam had sunk to depths varying from 34 feet to 87 feet. Before the third seam was formed, the second horizontal plane of coal had sunk irregularly to depths varying from 47 feet to 149 feet. The third plane of coal, in turn, settled down in some places 31 feet and in others 69 feet before the fourth seam was laid down; while the plane of the fourth was found to show an irregular subsidence of from 13

feet to 40 feet before the fifth and highest marsh became ready for its luxuriant vegetation. It would be discourteous in me to question the accuracy of the identification of the seams or of the measurements between them. If these figures represent facts, they, with all facts, however stubborn, have their rights. These facts, however, appear to me to have unusual stubbornness. It is barely possible that where we have sands and clay sediments in horizontal alternation, filling the interval between two seams of coal, there might have been a slightly greater compression and condensation of the mass of soft sediments than of the sand, and hence the plane of the coal might show a trifling undulation. I have not, however, observed any such cases.

The buried vegetation of the coal-marshes reappears, after the lapse of long geological ages, in three pretty well marked varieties of coal, viz., the more bituminous or caking, the dry splint and the cannel—all grouped under the general head of bituminous as distinguished from the metamorphic anthracite. The more bituminous or pitch coal appears to be the natural or normal form which the unaltered vegetation took when buried. Any one familiar with the details of our bituminous coal fields, has often seen in the shales and slates films of this bright resinous coal, where single trunks or branches of *Sigillaria lepidodendra*, or of large ferns, like *Pecopteris arborescens*, have been buried with an almost perfect exclusion of air. Such films of coal are derived, as Dawson has abundantly proved, from the bark layers of the tree, the interior portion of the tree always, in these cases, disappearing without adding to the quantity of coal. The same high authority regards the mineral charcoal common in most seams of coal as the product of the partially decomposed inner bark, and of the more woody portion of the tree with portions of other vegetation. In some cases which have fallen under my observation, where there was reason to believe that the tree had been prostrated while a living tree and buried without any previous decomposition, both barks were converted into bright and resinous coal. From this we may, perhaps, infer that if the whole mass of vegetation forming a coal seam were completely buried without any previous decomposition, we might expect the whole to be converted into bright coal. Sometimes we find the coal very bright and pitch-like in a considerable portion of the seam, showing scarcely any mineral charcoal or laminations of duller color, which latter are generally supposed to indicate the more decomposed vegetable matter of leaves, fronds and smaller plants; but such cases are rare. Dawson thus writes: "I

would also observe that, though in the roof shales and other associated beds it is usually only the cortical layer of trees that appear as compact and bituminous coal, yet I have found specimens which show that, in the coal seams themselves, true woody tissues have been converted into structureless coal, forming like the coniferous trees converted into jet in more modern formations, thin bands of very pure bituminous material." The probability is that the less the sub-aërial decay, the more perfectly bituminized and structureless becomes the resulting coal. Nothing would be so likely to prevent such decay as immersion in water, and such immersion must play an important part in the formation of the more highly bituminous and coking coals. "In the putrefaction of wood under water or imbedded in aqueous deposits," says Dawson, "a change occurs in which the principal loss consists in carbon and oxygen; and the resulting coaly product contains proportionally more hydrogen than the original wood. This is the condition of the compact bituminous coal. * * * * The mineral charcoal results from sub-aërial decay, the compact coal from sub-aqueous putrefaction more or less modified by heat and exposure to air."

Prof. T. S. Hunt, in the *Canadian Naturalist*, July, 1861, gives the results of the analyses by various chemists, taken chiefly from Bischof's *Chemical Geology*, showing the relative proportions of the elements in wood, peat, coal, asphalt and petroleum. He states that "the nitrogen, which, in most cases, was included with the oxygen in the analysis, has been disregarded, and the oxygen and hydrogen, for the sake of comparison, have been calculated for twenty-four equivalents of carbon."

1.	Vegetable fibre or cellulose,	$C_{24}\ H_{20}\ O_{20}$
2.	Wood, mean composition,	$C_{24}\ H_{18{\cdot}4}\ O_{16{\cdot}4}$
3.	Peat (Vaux),	$C_{24}\ H_{14{\cdot}4}\ O_{10}$
4.	" (Regnault),	$C_{24}\ H_{14{\cdot}4}\ O_{9{\cdot}6}$
5.	Brown coal (Schrötter),	$C_{24}\ H_{14{\cdot}2}\ O_{10{\cdot}6}$
6.	" (Woskresensky),	$C_{24}\ H_{13}\ O_{7{\cdot}6}$
7.	Lignite (Vaux),	$C_{24}\ H_{11{\cdot}2}\ O_{6{\cdot}4}$
8.	Lignite passing into mineral resin (Regnault),	$C_{24}\ H_{15}\ O_{3{\cdot}2}$
9.	Bituminous coal (Regnault),	$C_{24}\ H_{10}\ O_{3{\cdot}2}$
10.	" "	$C_{24}\ H_{10}\ O_{1{\cdot}7}$
11.	" "	$C_{24}\ H_{8{\cdot}4}\ O_{1{\cdot}2}$
12.	" "	$C_{24}\ H_{8}\ O_{0{\cdot}9}$
13.	" (Kühner and Grāger),	$C_{24}\ H_{7{\cdot}4}\ O_{1{\cdot}2}$

14. Bituminous Coal (mean comp.), (Johnston), . $C_{24}\ H_9\ O_3$–O_4
15. Albert coal (Wetherell), ... $C_{24}\ H_{15\cdot9}\ O_{1\cdot6}$
16. Asphalt, Auvergne, ... $C_{24}\ H_{17\cdot7}\ O_{2\cdot3}$
17. " Naples, ... $C_{24}\ H_{14\cdot6}\ O_2$
18. Elastic bitumen, Derbyshire (Johnston), . . $C_{24}\ H_{22}\ O_{0\cdot3}$
19. Bitumen of Idria . . . . . $C_{24}\ H_8$
20. Petroleum and Naphtha,. . . . $C_{24}\ H_{24}$

These analyses are very attractive and valuable.

It is an interesting fact that the beautiful, smooth, vertical planes, which are found, more or less, in all coals, and which, in the same seam always having a uniform direction, determine the "face" of the coal, are far more abundant in the more resinous or pitch-like varieties. The thin pellicles of bright coal formed when a trunk of *Sigillaria* or other tree is buried in the slates, show these planes in great perfection and profusion. In whatever way the tree may lie, these vertical joints, if joints they may be called, always maintain a constant direction with reference to the points of the compass. In the coal-seams of Southern Ohio, the direction of these planes is proximately east and west, the variation not often being greater than 15° north of west and south of east. In West Virginia, I have found a seam of coal in which these planes held a northwest and southeast direction. The splint or black coals of Clay county, Indiana, are said to have two sets of such planes crossing each other, so as to give the blocks a slightly diamond shape.

The *splint coal* possesses a less pitch-like character, is more laminated in structure, and generally contains more mineral charcoal. The laminæ are harder and tougher and much more difficult to break. The fracture of the coal is sharply ragged and splintery and never vertical, as in the case of the more bituminous and shining varieties. It is evident that the vegetation was more exposed to alternate conditions of wet and dry, was thoroughly leached and brought thereby into a condition of fibrous toughness. Such coal compares with the more bituminous and pitch-like coal as wrought-iron compares with brittle cast-iron. The splint coal separates into large and firm tabular plates, which return to the blow of hammer a sound almost metallic in character.

Sometimes a seam of coal passes, by almost imperceptible gradations, from the highly bituminous into splint, and in a few instances I have found layers of each alternating in the same seam.

The splint coal is always an open and dry burning coal. It never

melts and swells in the fire like the caking variety, and for this reason it is specially adapted, in the raw state, to the smelting of iron.

Cannel coal. We should expect that in the swampy flats of the Coal Period there would be wet places filled with muck or vegetable mud, similar to what we often find in such swamps to-day. In the modern muck-bog the structure of the vegetation, through chemical reactions, is almost entirely obliterated, and there results a fine soft mud, which, when dried, forms a dark and almost impalpable powder. We find the proof of the existence of similar locations of vegetable mud in the old coal-producing areas. They were probably not the only wet places, for what has already been said of the origin of the more bituminous or pitch-like coals implies the existence of much water, but they were the wet places in which the vegetation became so thoroughly decomposed that when afterward buried, compressed and bituminized, it was changed into a hard compact stratum of coal, showing little lustre, generally no lamination, and breaking with conchoidal fracture. It is probable that there were vast quantities of vegetable mud formed which did not go to constitute seams of cannel coal, but were floated away by currents, and mingling with mineral sediments settled in the more quiet waters of the shallows, thus forming strata of bituminous slates and shales. Such strata are very common and, when carefully traced, are generally found to align themselves on the geological horizons of seams of coal. Hence, they serve as excellent guides as we traverse the breaks of continuity in a coal seam.

Göppert, in some experiments, found that "mosses lying 6 or 8 inches under water were decomposed rapidly, while those from 1 foot to 3 feet below the surface were tolerably preserved for 15 months." This fact would make it not improbable that it was chiefly in quite shallow water that the muck-producing decay took place, while the "subaqueous putrefaction" of the vegetation forming the pitch coal, spoken of by Dawson, required a deeper submergence and a more perfect exclusion of the air. In the water over the accumulating vegetable mud, fishes, molluscs and other forms of life sometimes abounded, and these were entombed in the mud.

(To be continued.)

ON SOIL ANALYSES AND THEIR UTILITY.

(*Abstract of a Paper read at the Dubuque Meeting of the Am. Ass'n Adv. Science, by* EUGENE W. HILGARD, *State Geologist of Mississippi.*)

In this paper the author reviews the objections against the utility of soil analyses, as set forth by Prof. S. W. Johnson, of Yale, in an article published in the American Journal of Science for Sept., 1861. He states that, while agreeing with Prof. Johnson in many of his strictures, he thought some of the objections urged inapplicable to large classes of soils in the South and West, while others were avoidable. With this view he had continued, or caused to be continued, the analytical researches already carried on for some time on the soils of the State of Mississippi. From the results obtained in the analyses of over 200 soils and subsoils, he concludes that highly important practical information can be derived from series of analyses, carried out upon a uniform plan, upon soils directly derived from uniform or uniformly variable formations, as is the case to a great extent in the South and West. The cardinal objection, that representative specimens cannot be obtained, however weighty in mountainous districts and on manured soils, becomes untenable on the prairies and even in the rolling uplands of the South, provided due care is exercised in sampling the soil—an operation second in difficulty only to the analysis itself, and not to be trusted to inexperienced hands.

For the purposes of soil analysis no commercial reagents can be used, since however pure they may have been when originally prepared, the acids, ammonia, etc., become contaminated when kept in glass bottles for a length of time. All liquid reagents used must be specially prepared in small quantities as required. The solvent to be used should not go as deep as H F, or fusion with alkaline earths; nor fall so far short of what the rootlets of plants can perform in the way of solution as carbonic acid. Hydrochloric acid of uniform strength, sp. gr. 1·11 to 1·12, as obtained by steam distillation, was used in all analyses for a uniform length of time, and all operations were performed in as uniform a manner as the variety of materials permitted.

We can thus obtain *comparative* and *comparable* data, giving not the entire amounts of nutritive soil ingredients present, but the amounts respectively accesible to the action of one and the same degree of solvent action, supposing, of course, the nature of the materials to be substantially the same. We can thus compare, not any

two soils from distant localities, but series of soils of essentially similar origin.

The object being, not an exhaustive determination of *all* the physical and chemical characters of the soil, but something practically analogous to the assay of ores, the chemist should on the one hand be relieved from the numerical determination of such factors as can, with sufficient correctness, be estimated comparatively, while on the other hand he should avail himself, in the practical interpretation of his results, of all that an accurate study in the field, coupled with whatever experience may have been acquired by cultivators, can afford in the way of facts and suggestions. Mere columns of figures can be of little value except as showing a great excess or scarcity of some important ingredient.

Of the latter, *potash, phosphoric acid* and *lime* are those whose presence in greater or less quantity chiefly determine the chemical value and character of the soil; vegetable matter or "humus" must also be accurately determined, since upon it, as well as upon the clay present, chiefly depends the important absorptive power both for ammonia and moisture.

The results of silt-analysis being as inadequate to determine that factor as is the chemical composition, the direct determination of the absorbing power for aqueous vapor has been studied, with this result: that for the ordinary range of temperature in a saturated atmosphere, the co-efficient of absorption is sensibly constant for one and the same soil, being for—

Very sandy soils, . .	1·5 to 2·0 per cent.
Loam soils, . . .	5·0 to 8.0 "
Heavy clay soils, . .	12·0 to 15.0 "

These numbers, representing with tolerable accuracy what is practically expressed "heaviness" and "lightness;" large amounts of humus and ferric oxide, however, interfere occasionally with the practical correctness of the estimate so formed.

The author's conclusions may be summed up thus:

1. While the analysis of *cultivated and manured* soils can seldom give us information of much practical value, from the difficulty of obtaining representative specimens; the same is not true of the impalpable virgin soils directly derived from widespread quaternary formations, as is extensively the case in the South and West. The soils of large tracts of country can thus be classified into a few typical ones and their intermixtures.

2. Series of analyses of representative specimens, made on a uni-